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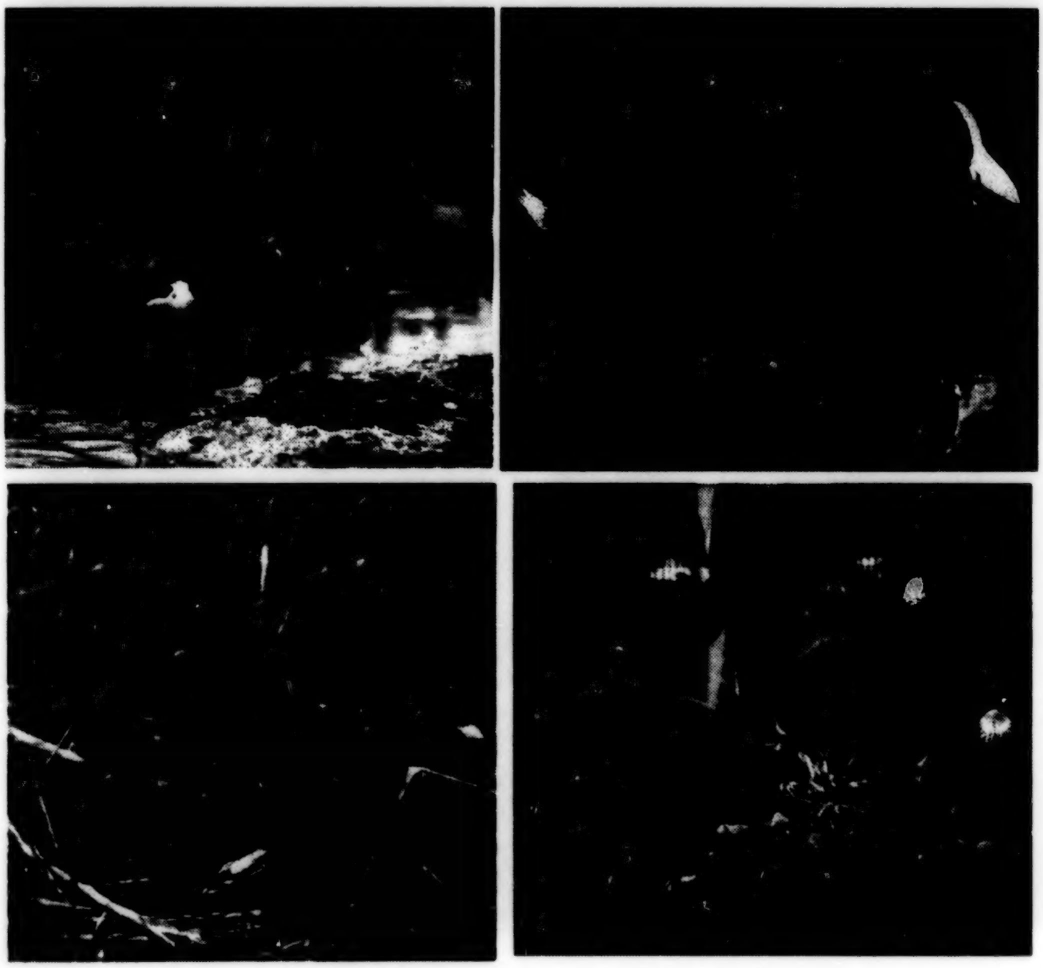
Draft Revised Recovery Plan for Hawaiian Waterbirds
Second Revision



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DRAFT
REVISED RECOVERY PLAN FOR HAWAIIAN WATERBIRDS
SECOND REVISION

May 1999

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Date: ____________________________________

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DISCLAIMER PAGE

Recovery plans delineate reasonable actions that are believed necessary to recover and protect the species. Plans are prepared by the U.S. Fish and Wildlife Service, sometimes with the assistance of recovery teams, contractors, State agencies, Tribal agencies, and others. Objectives will be attained and any necessary funds made available subject to budgetary and other constraints affecting the parties involved, as well as the need to address other priorities. Costs indicated for task implementation and time for achievement of recovery are only estimates and subject to change. Recovery plans do not necessarily represent the views nor the official positions or approval of any individuals or agencies involved in plan formulation, other than the U.S. Fish and Wildlife Service. Recovery plans represent the official position of the U.S. Fish and Wildlife Service only after they have been signed by the Director or Regional Director as approved. Approved recovery plans are subject to modification as dictated by new findings, changes in species status, and the completion of recovery tasks.

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DRAFT REVISED RECOVERY PLAN
FOR HAWAIIAN WATERBIRDS
SECOND REVISION
EXECUTIVE SUMMARY

Current Species Status: The four birds covered by this recovery plan, Hawaiian duck or koloa maoli (*Anas wyvilliana*), Hawaiian coot or 'alae ke'oke' (*Fulica alai*), Hawaiian moorhen or 'alae 'ula (*Gallinula chloropus sandvicensis*), and Hawaiian stilt or ae'o (*Himantopus mexicanus knudseni*) are all listed as endangered. Hawaiian coots and stilts are found on all of the main Hawaiian Islands except Kahoolawe; Hawaiian ducks are found on the islands of Niihau, Kauai, Oahu, Maui, and Hawaii; and Hawaiian moorhens are found only on the islands of Kauai and Oahu. Accurate population estimates are not available; however, none of these species are thought to number more than 2,500 individuals, with the exception of the coot population, which is estimated to fluctuate between 200 and 4,000 birds statewide. Trend data shows coot and stilt populations are either stable or increasing over the past 3 decades.

Habitat Requirements and Limiting Factors: These species are found in a variety of wetland habitats including freshwater marshes, coastal ponds, taro patches, irrigation ditches, and in the case of the koloa maoli, montane streams and swamplands. The primary causes of the decline of these four species have been the loss of wetland habitat, and in the past, hunting. Factors that continue to be detrimental include predation by introduced mammals, invasion of wetlands by alien plants, hybridization, disease, and possibly environmental contaminants.

Recovery Objective: Downlist to threatened status and then delist.

Recovery Criteria: For downlisting, the following conditions must be met:

Koloa maoli

- The threat of hybridization with mallards is removed from all islands;
- all wetlands listed in Table 1, on the islands of Kauai, Oahu, and Hawaii

IV

are protected and managed, following the management practices outlined in this plan;

- multiple, viable breeding populations are present on Kauai/Niihau, Oahu and Hawaii; and
- statewide koloa maoli population numbers show a stable or increasing trend, above a minimum of 2,000 birds, for at least 5 consecutive years.

Coot

- The wetlands listed in Table 1, on the islands of Kauai/Niihau, Oahu, and Maui/Molokai are protected and managed, following the management practices outlined in this plan;
- multiple, viable breeding populations exist on Kauai/Niihau, Oahu, Hawaii, and Maui/Molokai; and
- statewide coot population numbers show a stable or increasing trend, above a minimum of 1,800 birds, for at least 5 consecutive years.

Moorhen

- The wetlands listed in Table 1, on the islands of Kauai, Oahu, and either Maui/Molokai or Hawaii are protected and managed, following the management practices outlined in this plan;
- multiple, viable breeding populations exist on Kauai/Niihau, Oahu, and either Maui/Molokai or Hawaii; and
- statewide moorhen population numbers show a stable or increasing trend, above a minimum of 1,500 birds, for at least 5 consecutive years.

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Stilt

- The wetlands listed in Table 1, on the islands of Kauai/Niihau, Oahu, and Maui/Molokai are protected and managed, following the management practices outlined in this plan;

- multiple, viable breeding populations exist on Kauai/Niihau, Oahu, Hawaii, and Maui/Molokai; and

- statewide stilt population numbers show a stable or increasing trend, above a minimum of 1,500 birds, for at least 5 consecutive years.

For delisting, the following criteria must be met:

Koloa maoli

- The wetland areas specified for downlisting and the primary habitats listed in task 21 are protected and managed, following the management practices outlined in this plan;

- multiple, viable breeding populations exist on Kauai/Niihau, Oahu, Maui/Molokai, and Hawaii; and

- statewide koloa maoli population numbers show a stable or increasing trend, above a minimum of 2,000 birds, for at least 10 consecutive years.

Coot

- The wetland areas specified for downlisting, and the primary habitats listed in task 21 are protected and managed, following the management practices outlined in this plan;

- multiple, viable breeding populations exist on Kauai/Niihau, Oahu, Maui/Molokai, and Hawaii; and

- statewide coot population numbers show a stable or increasing trend, above a minimum of 2,000 birds, for at least 10 consecutive years.

Moorhen

- The wetland areas specified for downlisting, and the primary habitats listed in task 21 are protected and managed, following the management practices outlined in this plan;

- multiple, viable breeding populations exist on Kauai/Niihau, Oahu, Maui/Molokai, and Hawaii; and

- statewide moorhen population numbers show a stable or increasing trend, above a minimum of 2,000 birds, for at least 10 consecutive years.

Stilt

- The wetland areas specified for downlisting, and the primary habitats listed in task 21 are protected and managed, following the management practices outlined in this plan;

- multiple, viable breeding populations exist on Kauai/Niihau, Oahu, Maui/Molokai, and Hawaii; and

- statewide stilt population numbers show a stable or increasing trend, above a minimum of 2,000 birds, for at least 10 consecutive years.

Actions Needed:

1. Manage protected wetland habitats.
2. Protect and manage additional primary wetland habitats.
3. Conduct research to better define limiting factors, determine recovery objectives, and improve management techniques.
4. Conduct a public education and information program.
5. Validate recovery objectives.

Total Estimated Cost of Recovery ($1,000's):

Year	Need 1	Need 2	Need 3	Need 4	Need 5	Total
1999	1601.0	0.0	900.0	160.0	0.0	2661.0
2000	1589.0	8.0	900.0	160.0	0.0	2657.0
2001	1579.0	110.0	900.0	6.0	0.0	2595.0
2002	1858.0	500.0	620.0	6.0	0.0	2984.0
2003	1838.0	900.0	620.0	6.0	0.0	3364.0
2004	1898.0	1080.0	0.0	6.0	0.0	2984.0
2005	1459.0	1281.0	0.0	6.0	20.0	2766.0
2006	1459.0	1481.0	0.0	6.0	20.0	2966.0
2007	1439.0	1661.0	0.0	6.0	1.0	3107.0
2008	1439.0	1602.0	0.0	6.0	0.0	3047.0
2009	1439.0	1602.0	0.0	6.0	0.0	3047.0
2010	1438.0	1601.0	0.0	6.0	0.0	3045.0
2011	1438.0	1601.0	0.0	6.0	0.0	3045.0
2012	1438.0	1601.0	0.0	6.0	0.0	3045.0
Total*	21912.0	15028.0	3940.0	392.0	41.0	41313.0

*Some costs are yet to be determined.

Date of Recovery: Downlisting to threatened could be initiated in 2006 and delisting could be initiated in 2012, if recovery criteria are met.

TABLE OF CONTENTS

PART I. INTRODUCTION

1. Brief Overview 1

2. Endangered Species Accounts

Koloa maoli (Hawaiian Duck) (*Anas wyvilliana*) 3
    Taxonomy 3
    Species Description 4
    Historic Range and Population Status 4
    Current Range and Population Status 5
    Life History 8
    Habitat Description 8

Hawaiian Coot (*Fulica alai*) 9
    Taxonomy 9
    Species Description 10
    Historic Range and Population Status 10
    Current Range and Population Status 10
    Life History 13
    Habitat Description 14

Hawaiian Moorhen (*Gallinula chloropus sandvicensis*) 15
    Taxonomy 15
    Species Description 15
    Historic Range and Population Status 16
    Current Range and Population Status 16
    Life History 18
    Habitat Description 19

Hawaiian Stilt (*Himantopus mexicanus knudseni*) 20
    Taxonomy 20
    Species Description 20
    Historic Range and Population Status 20
    Current Range and Population Status 21
    Life History 24
    Habitat Description 25

3. Reasons For Decline And Current Threats 25

4. Conservation Measures 29
5. General Recovery Strategy 37

PART II. RECOVERY

1. Recovery Objectives 42

2. Step-Down Outline 46

3. Step-Down Narrative 52

4. References 75

PART III. IMPLEMENTATION SCHEDULE 81

APPENDIX A - Individuals Contacted During Plan Review 95

APPENDIX B - Core Wetland Habitat Location Maps 98

APPENDIX C - Waterbird Counts at Wetland Habitats in the Hawaiian Islands, 1974 to 1997 103

Appendix C1. Counts of koloa maoli at wetland habitats in the Hawaiian Islands, 1974 to 1997 104

Appendix C2. Counts of Hawaiian coots at wetland habitats in the Hawaiian Islands, 1974 to 1997 105

Appendix C3. Counts of Hawaiian moorhens at wetland habitats in the Hawaiian Islands, 1974 to 1997 106

Appendix C4. Counts of Hawaiian stilts at wetland habitats in the Hawaiian Islands, 1974 to 1997 107

X

List of Figures

Figure 1. Map of the main Hawaiian Islands 2

Figure 2. Known distribution of koloa maoli and mallard in the Hawaiian Islands 6

Figure 3. Known distribution of Hawaiian coot in the Hawaiian Islands 11

Figure 4. Known distribution of Hawaiian moorhen in the Hawaiian Islands 17

Figure 5. Known distribution of Hawaiian stilt in the Hawaiian Islands 22

Figure 6. Core wetland localities on the islands of Niihau and Kauai 99

Figure 7. Core wetland localities on the island of Oahu 100

Figure 8. Core wetland localities on the islands of Molokai and Maui 101

Figure 9. Core wetland localities on the island of Hawaii 102

List of Tables

Table 1. Secured wetland habitats in the Hawaiian Islands, January 1994 31

Table 2. Specific recovery actions recommended for Hawaiian wetlands 39

I. INTRODUCTION

1. **Brief Overview**

A total of 106 endemic species and subspecies of birds have been described from the Hawaiian Islands (Pyle 1988, Olson and James 1991). Of these, 35 became extinct before the arrival of Captain Cook in 1778, and an additional 23 since then, leaving 48 extant endemic taxa (Robert Pyle, Bernice Pauahi Bishop Museum, personal communication 1994). The Hawaiian Islands historically supported a diverse array of waterbirds in wetland and forest habitats. During the past 2,000 years of human presence, all of Hawaii's endemic rails, flightless geese, and an ibis have become extinct (Olson and James 1992). This massive extinction is attributed to the impacts of humans and the plants and animals they introduced to Hawaii. Polynesian settlers and Europeans have both played significant roles in the alteration of Hawaiian ecosystems and the resulting extinctions of species (Olson and James 1991).

The six extant species of endemic waterbirds are koloa maoli or Hawaiian duck (*Anas wyvilliana*), Laysan duck (*A. laysanensis*), Hawaiian coot (*Fulica alai*), Hawaiian stilt (*Himantopus mexicanus knudseni*), Hawaiian moorhen (*Gallinula chloropus sandvicensis*), and nene or Hawaiian goose (*Branta sandvicensis*). All of these species require wetlands for their survival. The Laysan duck and the nene are covered by separate recovery plans (U.S. Fish and Wildlife Service 1982, 1983a). The four species addressed in this recovery plan are the Hawaiian duck, coot, moorhen, and stilt. These species are currently found on various "main Hawaiian Islands" (Figure 1). The term "main Hawaiian Islands" refers to the following: Niihau, Kauai, Oahu, Maui, Molokai, Lanai, Kahoolawe, and Hawaii (also known as "the Big Island").

Historic declines are primarily attributed to hunting. The primary present cause of the decline of these four species of endangered Hawaiian waterbirds has been the loss of wetland habitat.

Continuing threats to these birds include predation by introduced mammals, invasion of wetlands by alien plants and fish, hybridization, disease, and possibly environmental contaminants (U.S. Fish and Wildlife Service 1983a).

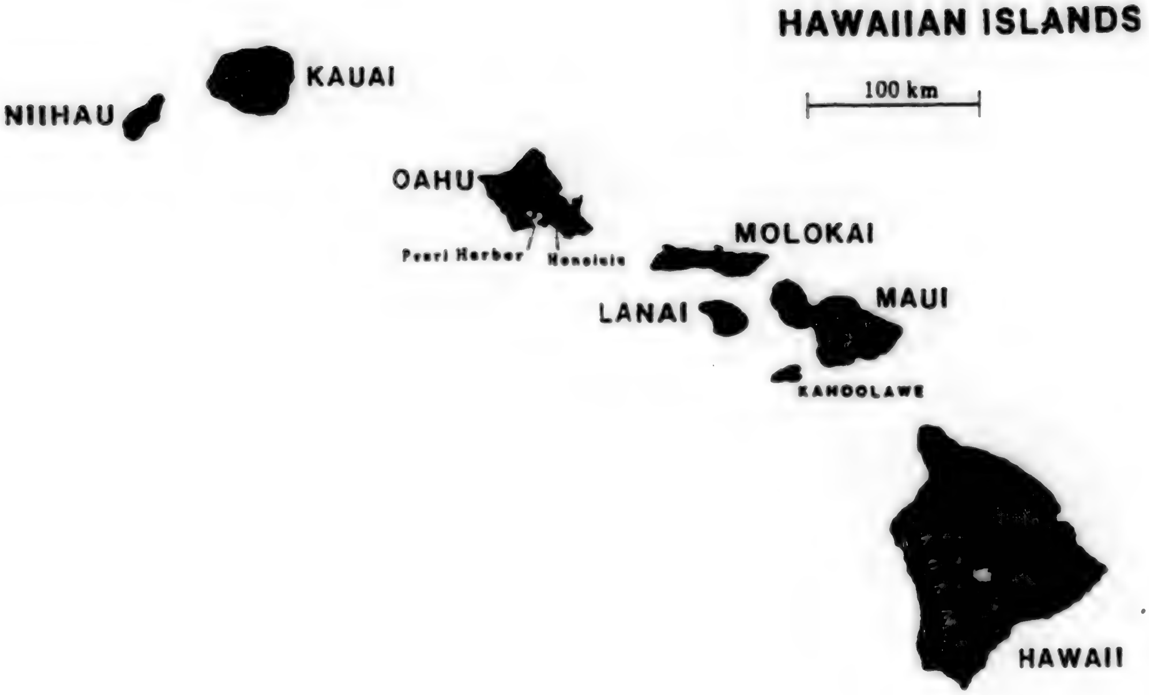

Figure 1. Map of the main Hawaiian Islands

The Hawaiian duck and moorhen were declared federally endangered species in 1967 (U.S. Fish and Wildlife Service 1967) and assigned recovery priority numbers of 2 and 9, respectively. The Hawaiian coot and stilt were added to the Federal endangered species list in 1970 (U.S. Fish and Wildlife Service 1970) and assigned recovery priority numbers of 15 and 9, respectively. Recovery priority numbers are assigned on a scale of 1 to 18 (1C being highest priority), using a system devised by the U.S. Fish and Wildlife Service (U.S. Fish and Wildlife Service 1983b). Critical habitat has not been declared for any of these four species.

Past conservation efforts have included a hunting ban, protection of habitat through establishment and management of National Wildlife Refuges and State sanctuaries, population monitoring, numerous research projects, and the release of captive-bred koloa maoli.

2. Endangered Species Accounts

HAWAIIAN DUCK or koloa maoli (*Anas wyvilliana*)

Taxonomy

The Hawaiian duck or koloa was first described in 1851 (American Ornithologists' Union 1983) as related to the mallard (*A. platyrhynchos*) or the Pacific black duck (*A. superciliosa*). It has since been classified as either a full species or a subspecies of these two related species. Recent genetic studies indicate that koloa are distinct at the species level and are closely related to the North American mallard complex (Browne *et al.* 1993, Cooper *et al.* 1996, J. Rhymer, University of Maine, personal communication 1997). However, the species appears to be more closely allied with mottled (*A. fulvigula*) and American black (*A. rubripes*) ducks (Judith Rhymer, National Zoo, personal communication 1993). The American Ornithologists' Union maintains the koloa as a full species (American Ornithologists' Union 1983). The koloa is believed to be a recent colonist of the islands (R. Fleischer, National Zoo, personal communication 1993). Allozymic data suggest that there has been extensive hybridization between koloa and mallards on Oahu, with the near disappearance of koloa alleles, but there is only slight evidence of hybridization on Kauai (Browne *et al.* 1993).

Species Description

The koloa is a small, drab-brown duck that differs in many characteristics from the mallard. Both sexes are mottled brown and similar to a female mallard. Males usually have darker head and neck feathers, are slightly larger, and their bill is more olive-colored than the orange tone found in females (Swedberg 1967). Males also have brighter (orange) feet than females. Both sexes have emerald green to blue speculums (brightly colored areas on the wings), bordered anteriorly and posteriorly by white. Plumage of first year male koloa resemble the eclipse (nonbreeding) plumage of a male mallard.

Historical Range and Population Status

Koloa were known historically from all of the main Hawaiian Islands, except Lanai and Kahoolawe. There are no population estimates prior to 1940, but it is likely that koloa were fairly common in natural and farmed wetland habitats. The cultivation of taro (*Colocasia esculenta*), an agricultural crop grown in a pond-like environment, initially provided a considerable amount of wet agricultural habitat (Swedberg 1967). Rice (*Oryza sativa*) cultivation from the late 1800's to the 1940's continued to provide wetland habitat for koloa. A decline in flooded agriculture occurred by 1900, but there were still about 7,700 hectares (19,000 acres) of taro and 6,500 hectares (16,000 acres) of rice at that time (Bostwick 1982). Even before contact with Europeans, Hawaiians developed a considerable amount of artificial wetland-agricultural acreage (Swedberg 1967).

Koloa numbers declined noticeably early in the 20th century. Predation of eggs and chicks by rats (*Rattus sp.*), mongooses (*Herpestes auropunctatus*), dogs (*Canis familiaris*), cats (*Felis catus*), introduced fish, and birds; habitat reduction (due to changes in agricultural practices and urban development); and local hunting pressure brought about a significant population decline of koloa (U.S. Fish and Wildlife Service 1983b). Introduced ungulates such as pigs (*Sus scrofa*) and goats (*Capra hircus*) have significantly impacted koloa nesting habitat along Kauai's montane streams (Thomas Telfer, Hawaii Division of Forestry and Wildlife and Andrew Engilis Jr., Ducks Unlimited, personal communications 1992). In 1949, an estimated 500 koloa remained on Kauai, and about 30 on Oahu. At that time, koloa were considered an occasional visitor to the island of Hawaii, and were presumed extirpated on Maui and Molokai (Schwartz and Schwartz 1949). By 1960, they were apparently extirpated on Oahu when Kaelepulu Pond, the last koloa stronghold on Oahu, was modified as part of a housing development. By the 1960's, koloa were found only in small numbers on Kauai and probably on Niihau, but they have since been restored to Hawaii, Oahu, and Maui.

Current Range and Population Status

The wild koloa population in the State of Hawaii is estimated to be 2,500 birds (Engilis and Pratt 1993). Current populations are found on Kauai/Niihau, Oahu, Maui, and Hawaii (Figure 2) with an estimated 2,000, 300, 25, and 200 birds, respectively (Engilis and Pratt 1993, A. Engilis, personal communication 1997). Waterbird surveys conducted during the 1970's and 1980's showed a steady increase of birds in the State, peaking at 312 birds during the 1987 survey (Appendix C1). However, these surveys do not cover stream and montane wetlands where the main portion of the population is thought to exist. Biannual surveys of koloa suggest a seasonal movement of birds from lowland wetlands to more secluded habitats in summer. The summer survey declines could represent altitudinal movements, dispersal up stream valleys, or possibly a reclusive post-breeding molt period.

Kauai Population

The surviving population on Kauai has maintained itself without the release of captive-bred birds. Lowland surveys during the 1940's and 1950's estimated the population at 500 birds. Surveys in the mid 1960's provided an estimated population of 3,000 koloa (Swedberg 1967), mostly in remote, montane streams and valleys. This apparent increase was probably a result of the underestimation of birds in the mountainous stream habitat by earlier observers. The island population was estimated to be between 1,500 and 2,000 koloa in 1988 (T. Telfer, personal communication 1988). More recent estimates have also placed the Kauai population at 2,000 birds (Engilis and Pratt 1993).

The restoration of wetlands at Hanalei National Wildlife Refuge in the early 1990's has benefitted koloa. Prior to restoration, koloa were infrequent visitors. They are now regularly in Hanalei's restored wetlands. However, the majority of Kauai's population still nests along montane streams. Manmade ponds, particularly in Lihue, are also used by koloa. While these koloa readily mingle with ornamental waterfowl at these ponds, there are no known records of hybridization or hybrid koloa on Kauai.

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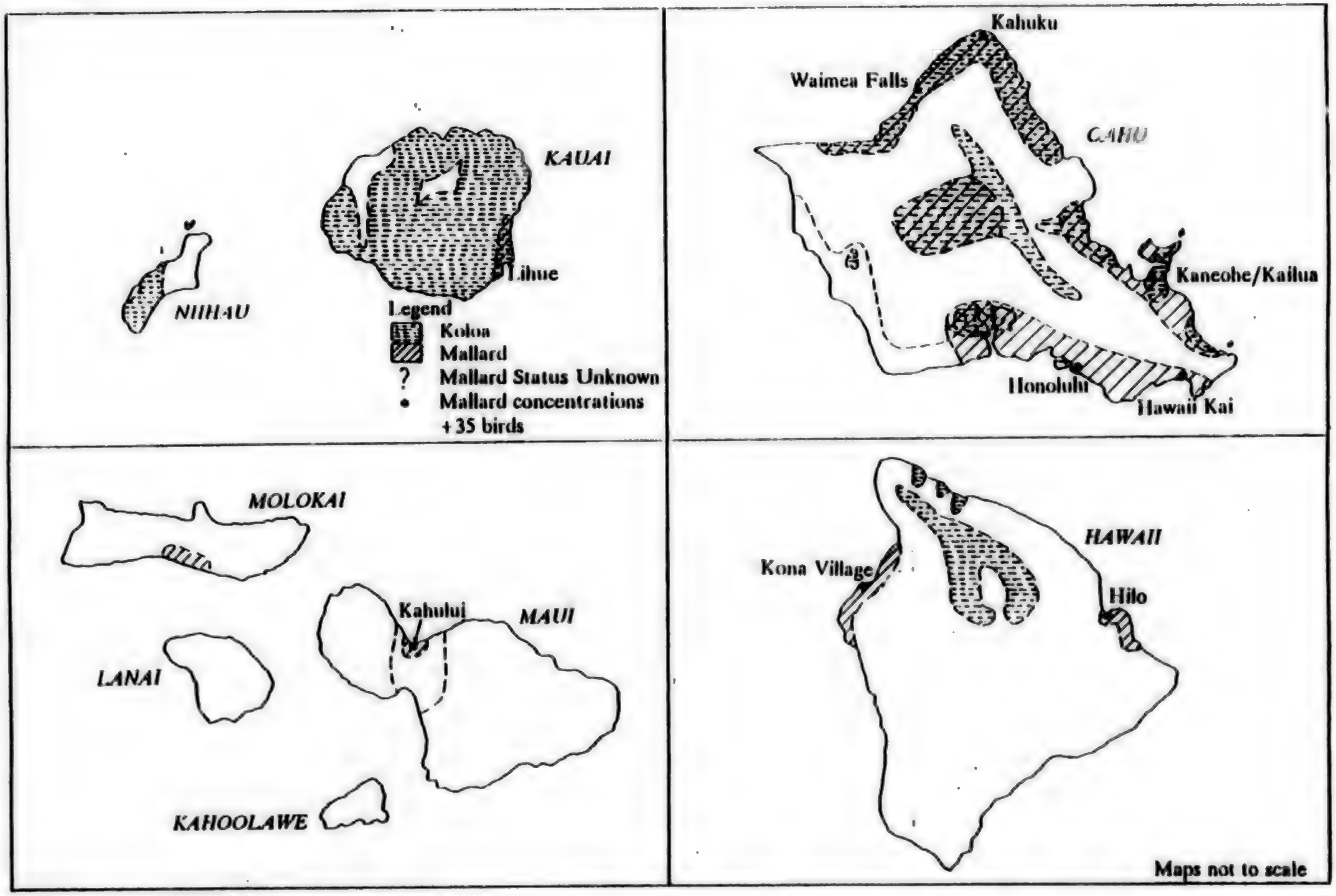

Figure 2. Known distribution of koloa and mallard in the Hawaiian Islands.

Oahu Population

Captive propagation and release of koloa between 1958 and 1982 reestablished the Oahu population. During this period, a total of 326 birds were released by state biologists at Kawainui Marsh (177), Nuupia Ponds (45), Waimea Falls Park (66), and Hoomaluhia City and County Park (38). State waterbird surveys showed an increasing population trend for koloa on Oahu from 1977 to 1987 (Engilis 1988). Since 1988, the Oahu population appears to be maintaining itself at about 300 or more ducks. However, the success of the reintroduction program on Oahu is questionable due to the high percentage of birds that are mallard-koloa hybrids. All koloa on Oahu that have been sampled for genetic characteristics have been hybrids despite plumage characteristics that might suggest otherwise (Griffin and Browne 1990).

Koloa frequent the wetland complexes on the windward coast (Kawainui, Hamakua, Heeia Marshes) and north shore (James Campbell National Wildlife Refuge, Punahoolapa, Haleiwa) of Oahu. In addition, several koloa have been reported from wetlands near Pearl Harbor and from Lualualei Valley on the leeward coast.

Maui Island Population

A captive-bird release of fewer than 12 koloa was conducted on Maui by the State of Hawaii in 1989. From these birds a small, breeding population is now established on Maui (F. Duvall, Hawaii State Division of Forestry and Wildlife, personal communication 1996). These birds frequent Kanaha and Kealia Ponds and sugar cane reservoirs in the valley portion of Maui. Hybrids with mallards have been documented as mallards were not eradicated from Maui prior to release of koloa (A. Engilis, personal communication 1997).

Hawaii Island Population

The current population estimate for the island of Hawaii is 200 birds (Engilis and Pratt 1993). Koloa were reestablished on the island of Hawaii between 1976 and 1982, when captive-bred birds were released in the Kohala Mountains. Some birds have dispersed from release sites and have been recorded up to 32 kilometers (20 miles) away (Giffin 1982). They have been observed using stock ponds in the Kohala Mountains, stream habitats of Pololu, Waimanu, and Waipio Valleys, and on Mauna Kea in stock ponds and larger montane streams. Successful breeding in the wild has been documented in the Kohala Mountains and on Mauna Kea at Hakalau National Wildlife Refuge. Hawaii's upper elevation koloa population is considered to be genetically pure and isolated from lowland populations of mallards; however, pair bonds between koloa and mallards have been observed in the Hilo area (A. Engilis, personal communication 1997).

Life History

Koloa breed year round, with a peak breeding period between January and May. In lowlands on Kauai, koloa form pair bonds between November and May with pairs dispersing to montane nesting localities. Some pairs find suitable breeding and nesting habitat in lowland wetlands. Pairs have been observed in the upper Alakai Swamp on Kauai, a montane habitat, in mid-February (A. Engilis, personal communication 1993). Nests are on the ground near water, but little else is known of their specific nesting habits. There have been few documented records of nesting in areas populated by humans, particularly where cats, dogs, or mongooses are common. Clutch size ranges from 2 to 10 eggs (mean = 8.3) (Swedberg 1967). Incubation lasts approximately 30 days, with most chicks hatching from April to June.

Koloa are usually found alone or in pairs and are wary, particularly when nesting or molting. Koloa may congregate in substantially larger numbers when exploiting rich food sources, particularly during winter. Concentrations of 200 or more ducks have been counted on Hanalei National Wildlife Refuge. They are strong flyers and usually fly at low altitudes. Banding recoveries on Kauai indicate that they move freely around the island (T. Telfer, personal communication 1993).

Koloa, like mallards, apparently are opportunistic feeders. Foods consumed by koloa include snails, dragonfly larvae, earthworms, grass seeds, rice, green algae, and seeds and leaf parts of wetland plants (Swedberg 1967). Feeding in wetlands and streams typically occurs in water 2 to 12 centimeters (1 to 5 inches) deep.

Habitat Description

Koloa historically used a wide variety of natural wetland habitats for nesting and feeding including freshwater marshes, flooded grasslands, coastal ponds, streams, montane pools, and forest swamplands from elevations ranging from sea level up to 3,000 meters (9,900 feet). Artificial wetlands (such as taro, lotus, shrimp, and fish ponds) supplement existing habitat and provide important feeding habitat for koloa. A typical stream type used by koloa on the Big Island is fairly narrow, 7 meters (23 feet) wide, swiftly flowing, strewn with boulders, and with heavily vegetated banks (Paton 1981). Swedberg (1967) estimates that 90 percent of the koloa on Kauai live along that island's extensive upland stream system, primarily from 300 to 1,200 meters (1,000 to 4,000 feet) elevation. Lowland habitats such as irrigation ditches, flooded ephemeral fields, reservoirs, mouths of larger streams, and wetlands on National Wildlife Refuges and State sanctuaries are also important as feeding and nesting sites.

Little information is available on the seasonal movements of koloa in response to the availability of seasonal and permanent wetland habitats between the summer (dry) and winter (wet) seasons. Interisland movements apparently occur between Niihau and Kauai, generally during winter (Engilis and Pratt 1993).

Species-specific Limiting Factor

Hybridization with feral mallards is the primary threat to the recovery of koloa. Damage of watershed stream systems by pigs, goats, and other feral ungulates may pose direct impacts to nesting habitat. Other limiting factors that threaten all of Hawaii's waterbirds are covered in the "Reasons for Decline and Current Threats" section of this plan.

HAWAIIAN COOT or 'alae ke'oke'o (*Fulica alai*)

Taxonomy

The Hawaiian coot (*Fulica alai*) or 'alae ke'oke'o is endemic to the Hawaiian Islands. This species probably originated from a group of migrant coots from continental North America that remained as residents in the islands (U.S. Fish and Wildlife Service 1983b). Its taxonomic status has been debated during the past several decades. Prior to 1993, the Hawaiian coot was the only form still considered a subspecies of the American coot (*F. americana*). The American Ornithologists' Union recognized the Hawaiian coot as a distinct species, following Pratt (1987), in the 39th supplement of the Checklist of North American Birds (American Ornithologists' Union 1993).

Species Description

The Hawaiian coot is smaller in body size than the related mainland species, but has a bulbous, white frontal shield distinctly larger than that of the American coot (Shallenberger 1977). A small percentage of the population has a red bulbous lobe at the top of the frontal shield and deep maroon markings at the tip of the bill, similar to the mainland species (Pratt 1978). A third form of Hawaiian coot has a full red frontal lobe. Coots have relatively long legs, with large, lobed toes. Male and female coots are similar in color. Adult coots have dark, slate-gray plumage and white undertail feathers. Immature coots are slate gray with buff-tipped contour feathers, smaller, dull white bills, and usually lack a well developed frontal shield.

Historical Range and Population Status

Hawaiian coots historically occurred on all of the larger Hawaiian Islands, with the exception of Lanai and Kahoolawe which apparently never had suitable waterbird habitat. Coots have always been most numerous on Oahu, Maui, and Kauai (Shallenberger 1977). It is likely that this bird was once fairly common in the large natural marshes and ponds and used additional wetland habitats created by Hawaiians for taro cultivation and large-scale fish production.

No population estimates are available for the years prior to the 1950's, however Schwartz and Schwartz (1949) identified a decline and potential threat of extinction in the first half of this century. Censuses from the late 1950's to the late 1960's indicated a population of fewer than 1,000, contributing to the listing of the Hawaiian coot as federally endangered. Coots are relatively easy to census and these data are considered fairly accurate in estimating minimum numbers in the State.

Current Range and Population Status

Hawaiian coots currently inhabit all of the main Hawaiian Islands except Kahoolawe (Figure 3). The statewide coot population is estimated to range between 2,000 and 4,000 birds, with Kauai, Oahu, and Maui supporting 80 percent of these birds (Engilis and Pratt 1993). Data from 1976 through 1996 shows a stable population trend in the State, based on the State Department of Land and Natural Resources waterbird survey records (Summer Counts 1987 to 1996, Appendix C2). The coot's ability to disperse and exploit seasonally flooded

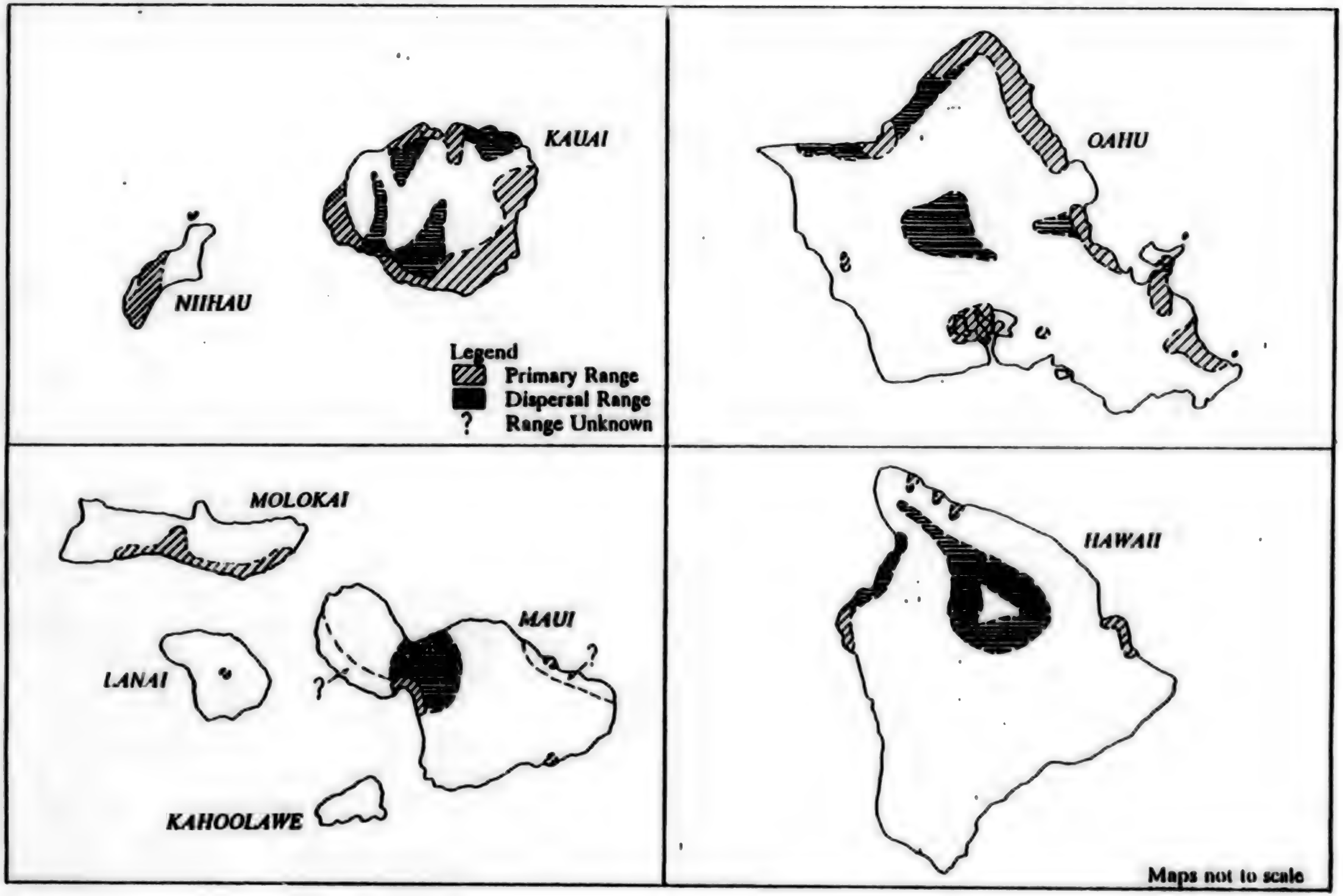

Figure 3. Known distribution of Hawaiian coot in the Hawaiian Islands.

wetlands has led biologists to the conclusion that populations will naturally fluctuate according to climatic and hydrologic conditions (Engilis and Pratt 1993). Population peaks of 2,000 or more birds (exceeding 4,000 birds in 1983) have occurred 8 times in the past 2 decades (Engilis 1988, A. Engilis, personal communication 1997).

Kauai and Niihau Populations

Niihau supports a large number of coots during winters (and some summers) when the extensive ephemeral lakes are flooded. Several authors have speculated that annual migration occurs between Kauai and Niihau, but statewide surveys indicate that these movements are less frequent, usually occurring when annual precipitation is above normal (Engilis and Pratt 1993).

On Kauai, coots are more frequent in lowland valleys (Hanalei, Opaekaa, and Huleia) and reservoirs; however, they have also been observed in plunge pools at elevations above 1,500 meters (4,950 feet) (State Department of Land and Natural Resources 1989).

Oahu Population

Oahu's extensive coastal wetlands provide excellent habitat for Hawaiian coots. The species is regularly recorded at wetlands along the east, west, and north shores, and less frequently at wetlands along the south shore and interior reservoirs, such as Lake Wilson and Nuuanu Reservoir. They are most abundant on natural wetlands at Kahuku Point and along the length of the windward side of Oahu. Aquaculture ponds for shrimp and fish production provide year-round foraging habitat for coots; however, nesting opportunities are limited on these ponds as vegetation is generally controlled along the banks, and predators (dogs, cats, and mongoose) can readily find nests around these ponds.

Maui, Molokai, and Lanai (Maui Nui) Populations

After Oahu, Maui Nui's population of coots is the largest in the State. Maui's two largest wetlands, Kanaha and Kealia Ponds, support most of the coots on Maui Nui. State waterbird surveys suggest that annual movements occur between these two wetlands. In addition to these wetlands, many of the reservoirs associated with former sugar cane (*Saccharum officinarum*) production that are still filled are frequented by coots. Nuu Pond, the only permanent, natural body of fresh water in southeast Maui, provides year-round nesting and foraging habitat. Molokai's coastal ponds and playa wetlands also support numerous coots, particularly Paialoa Pond. There is some evidence, from statewide waterbird surveys, that coots move between Maui and Molokai. These movements are not seasonal, but are sporadic and seem to correlate with periods of heavy rainfall (Engilis and Pratt 1993). The playa habitats on Molokai are usually dry, but flood in wet winters. Coots have become permanent residents at the Lanai City wastewater treatment ponds since 1988 (when they became operational). High counts of 48 birds were made by biologists from the State Department of Land and Natural Resources in 1995 and the trend shows an annual increase. Coots have been recorded nesting on the facility (State Department of Land and Natural Resources waterbird survey records 1988 to 1996).

Hawaii Island Population

The Big Island, with its limited wetland base, supports only a small population of Hawaiian coots. Four ponds on the island support the majority of these birds: Aimakapa and Opaeula on the Kona Coast, and Waiakea and Loko Waka Ponds in Hilo. The latter two ponds are in an urban area. The Big Island's coot population shows little seasonal fluctuation. From year to year numbers may vary as birds disperse to and from other islands. Since the construction of the Kona wastewater treatment ponds (near Kailua-Kona), the population now hovers around 200 birds on the Kona Coast and 75 birds on the Hilo Coast (Ducks Unlimited survey data 1995 to 1996).

Life History

Coots nest on open fresh and brackish ponds, on shallow reservoirs, irrigation ditches, and small openings of marsh vegetation (Udvardy 1960, Shallenberger 1977). They construct floating nests of aquatic vegetation in open water, or semi-floating nests anchored to emergent vegetation, or in clumps of wetland vegetation (Byrd *et al.* 1985). Open-water nests are typically anchored or semifloating mats of vegetation, constructed usually from water hyssop *(Bacopa monnieri*) and Hilo grass (*Paspalum conjugatum*). Nests in emergent vegetation are platforms constructed from buoyant stems of nearby vegetation, such as bulrush (*Scirpus* sp.) (Byrd *et al.* 1985). Nests have also been documented on shorelines or rocky islets (Marie Morin, National Park Service, personal communication 1994). Additional "false nests" may be constructed near the actual nest and are often used as loafing or brooding platforms.

Nesting occurs mostly from March through September, although some nesting occurs in all months of the year (Shallenberger 1977). The timing of nesting appears to correspond with seasonal weather conditions (Byrd *et al.* 1985, Engilis and Pratt 1993). Water levels are critical for nest initiation and success.

Clutch size ranges from 3 to 10 eggs, with an average of 5 eggs (Byrd *et al.* 1985). The incubation period ranges from 23 to 27 days, and chicks leave the nest soon after hatching. Renesting has been observed on Oahu.

Coots typically feed close to their nesting areas but will travel long distances when food is not locally available (Shallenberger 1977). Intra- and inter-island movements occur when reservoirs are drawn down and food sources become concentrated. They are generalists, obtaining food near the surface of the water, diving, or foraging in mud or sand. Coots also graze on upland grassy sites that are adjacent to wetlands. Food items include seeds and leaves of aquatic plants; various invertebrates including snails, crustaceans, and aquatic or terrestrial insects; tadpoles; and small fish (Schwartz and Schwartz 1949).

The Hawaiian coot is an active and, at times, gregarious species. As with its North American relative, the Hawaiian coot forms dense flocks. Flocking patterns in Hawaiian coots occur seasonally opposite of the American coot, with the former dispersing in winter and flocking in summer. Documented population fluctuations of coots can be explained by intraisland dispersal in relation to rainfall patterns and are not the result of North American coots migrating to the Hawaiian Islands (Engilis and Pratt 1993). Statewide waterbird surveys from 1977 to 1986 indicate that coots do migrate between islands in response to precipitation patterns. Most notably, Hawaiian coots periodically move between Niihau and Kauai and between Maui and Molokai (Engilis and Pratt 1993).

Habitat Description

The Hawaiian coot is typically a species of the coastal plain, usually found below 400 meters (1,320 feet) elevation, preferring wetland habitats with suitable emergent plant growth interspersed with open water. Some birds range to upland plunge pools above 1,500 meters (4,900 feet) on Kauai and montane stock ponds up to 2,000 meters (6,600 feet) on Hawaii (A. Engilis, personal communication 1992). Hawaiian coots prefer freshwater wetlands and taro patches, but will frequent freshwater reservoirs, brackish wetlands, or rarely saline water. Coots typically forage in water less than 30 centimeters (12 inches) deep, but can dive in water up to 120 centimeters (48 inches) deep. They prefer more open water than do moorhens, particularly for feeding. Optimum nesting habitat is generally in a 50:50 to 75:25 mix of dense emergent vegetation and open water. Large, deep ponds appear to provide only limited habitat for coots, particularly in leeward areas where strong winds can cause the formation of wavelets. Interspersion of robust emergent vegetation can help to reduce wind fetch. Shallow marshes or open ponds of 0.2 hectares (0.08 acres) have been found to be minimum sizes for American coot use (Weller and Spatcher 1965).

Loafing sites include logs, rafts of vegetation, narrow dikes, mud bars, artificial islands, and "false nests". Coots also loaf on open bodies of water such as reservoirs. Because of their ability to disperse to find suitable foraging habitat, ephemeral wetlands play an important part in the annual life-cycle. Ephemeral wetlands may support large numbers of coots during the nonbreeding season (e.g., up to 10 coots per acre (25 per hectare) year-round on Molokai wetlands, and concentrations of 600 or more birds on Niihau in winter) (Coleman 1978, Engilis 1988).

HAWAIIAN MOORHEN or 'alae 'ula (*Gallinula chloropus sandvicensis*)

Taxonomy

The Hawaiian moorhen (*Gallinula chloropus sandvicensis*) or 'alae 'ula is an endemic subspecies of the common moorhen (American Ornithologists' Union 1983). The Hawaiian subspecies is nonmigratory and originated presumably from stray migrant birds that colonized Hawaii from North America (Nagata 1983).

Species Description

Although the Hawaiian moorhen is recognized as distinct from its North American relative, there are no evident plumage, soft body coloration, or measurement differences from forms in North America (Wilson and Evans 1890 to 1899). Hawaiian moorhens superficially resemble the related Hawaiian coot but are noticeably smaller and possess a red shield over their red and yellow bill, and has a white flank stripe (Schwartz and Schwartz 1949). They are black above and slate blue below, with underwing coverts mostly white; their legs and feet are yellowish green, without lobes. The sexes are similar in appearance. Immature birds are olive brown to grayish brown, with a pale yellow or brown bill.

Historical Range and Population Status

No historical population estimates are available for the Hawaiian moorhen. It was common on the main Hawaiian Islands (except Lanai and Kahoolawe) in 1891 (Munro 1960). However, by the late 1940's, its status was "precarious" especially on Oahu, Maui, and Molokai (Schwartz and Schwartz 1949). As with coots, the moorhen is predominately a species of the coastal plains, generally below 125 meters (410 feet) elevation.

The moorhen is quite secretive and difficult to census, and even rough population estimates were lacking until the 1950's. Current census methodology for this species is regarded as inadequate (Griffin *et al.* 1989). Censuses in the 1950's and 1960's estimated no more than 57 individuals. The spread of aquaculture on Kauai and Oahu in the late 1970's and 1980's has probably led to an increase in the numbers of birds. In fact, aquaculture projects now support some of the highest concentrations of moorhens in the State (Engilis 1988).

Current Range and Population Status

Hawaiian moorhens inhabit the islands of Kauai and Oahu (Figure 4). However, due to the inability to adequately survey moorhen numbers, an accurate population estimate cannot be made.

The time-dependent, point-count method can provide accurate assessments of moorhen at a given site (Chang 1990). However, this method requires a substantial commitment of resources, making practical application unrealistic. The waterbird counts made at wetlands can give a rough idea of population trends (Appendix C3).

Kauai Population

Hawaiian moorhens are widely distributed in lowland wetlands and valleys of Kauai. Sizable populations exist in the Hanalei and Wailua River valleys. The irrigation canals on the Mana Plain of western Kauai also support birds, but accurate counts have proven logistically difficult (T. Telfer, personal communication 1988). Dense vegetation around lowland reservoirs may also support moorhens, but nesting is limited by deep water or severe water fluctuations. On Kauai, moorhens can be found in wetland agricultural areas such as taro fields.

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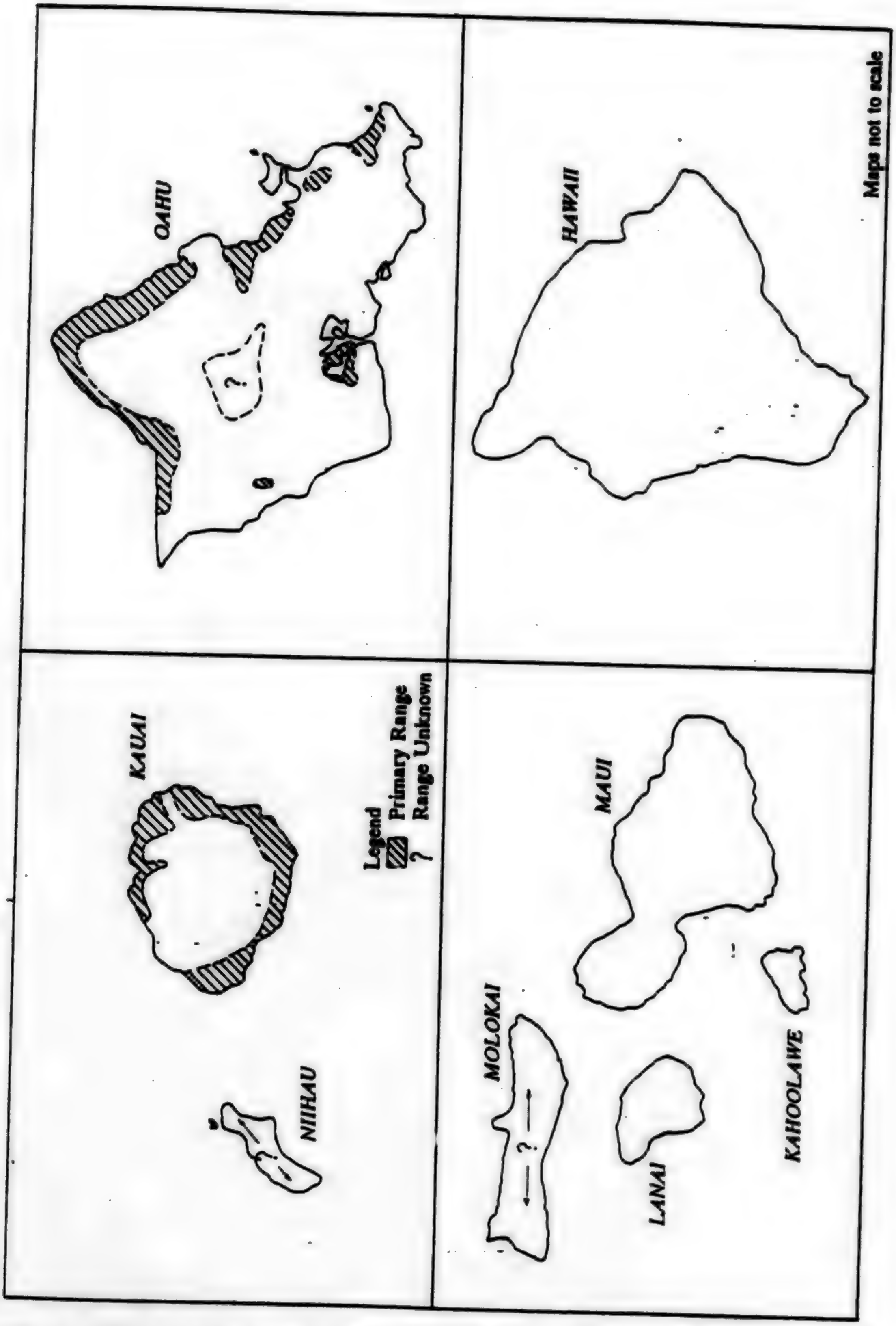

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Figure 4. Known distribution of Hawaiian moorhen in the Hawaiian Islands.

Oahu Population

Moorhens are widely distributed on Oahu, but are most prevalent between Haleiwa and Waimanalo. Small numbers exist in Pearl Harbor, where foraging occurs in semibrackish water. The population on the leeward coast is limited to Lualualei Valley. From 1977 to 1987, birds censused at the Haleiwa lotus fields alone accounted for 51.4 percent of the total counted in the winter State surveys (Engilis 1988).

Maui and Molokai Populations

Six marked birds were released by U.S. Fish and Wildlife Service staff on Molokai (Kakahaia National Wildlife Refuge) in June 1983. At least two of these were still present in January 1984, but there have been no confirmed sightings since 1985 (U.S. Fish and Wildlife Service, unpublished data). There are unsubstantiated reports of moorhen from the Keanae Peninsula, Maui (Shallenberger 1977) and from the Big Island (State Department of Land and Natural Resources records).

Life History

Little is known of the Hawaiian moorhen's breeding biology. Most nests are inconspicuously placed within dense emergent vegetation over shallow water. Moorhens generally nest in areas with standing freshwater, less than 60 centimeters (24 inches) deep. The emergent vegetation is folded over into a platform nest (Shallenberger 1977). Where emergent aquatic vegetation is insufficient, nests may be placed on the ground, but most have tall cover nearby. Apparently the particular species of emergent plant used for nest construction is not as important as stem density and vegetation height.

Nesting occurs year-round, but most activity extends from March through August (Shallenberger 1977). Nesting is apparently keyed to water levels and vegetation growth (U.S. Fish and Wildlife Service 1983b). Clutch size differed among two island investigations where it averaged 4.9 eggs (n = 87 nests) (Chang 1990) and 5.6 eggs (64 nests) (Byrd and Zeillemaker 1981). An average clutch size of 8.4 eggs was reported from seven North American moorhen sites (Byrd and Zeillemaker 1981). The incubation period is about 22 days.

Chicks swim away from the nest shortly after hatching. Moorhens are a precocial species (when first hatched, chicks are covered with down and able to walk), and the chicks are dependent on the parents for several weeks. Renesting and multiple broods during 1 season have been observed (Byrd and Zeillemaker

1981).

Little information is available on the feeding habits of the Hawaiian moorhen. Food items of this subspecies consist of algae, aquatic insects, and mollusks (Schwartz and Schwartz 1949). Telfer (unpublished data) found remains of snails, guava seeds, algae, and other plant material in stomachs of road-killed moorhens on Kauai. Seeds of grasses, parts of various plants, and other types of invertebrates are probably also included in the moorhen's diet. These birds are apparently opportunistic feeders, so the diet may vary with the particular habitat (Shallenberger 1977).

Hawaiian moorhens are the most secretive of the native waterbirds, preferring to forage in dense emergent vegetation. Most birds feeding along the edge or in the open quickly seek cover when disturbed. Moorhens are good swimmers and often cross open water to reach foraging sites. Hawaiian moorhens are generally sedentary; however, moorhens readily disperse in spring, presumably to breed (Nagata 1983). Dispersal may occur in relation to droughts or wet periods (Engilis and Pratt 1993).

Habitat Description

Hawaiian moorhen habitat consists of freshwater marshes, taro patches, reedy margins of water courses (streams, irrigation ditches, etc.), reservoirs, and wet pastures. Moorhens do not frequent brackish water and are not generally present in saline habitats. The conversion of aquaculture ponds in Kahuku, Oahu, from fresh to salt water resulted in an observed decline in moorhen numbers (Engilis and Pratt 1993). The densest moorhen nesting areas are Hanalei National Wildlife Refuge (taro fields) on the island of Kauai, and at the Kahuku and Ukoa wetlands, and Waialua lotus fields on Oahu.

The key features of habitat areas for moorhens are 1) dense stands of robust emergent vegetation near open water, 2) floating or barely emergent mats of vegetation, 3) water depth less than 1 meter (3.3 feet), and 4) freshwater as opposed to saline or brackish water. Interspersion of robust emergent vegetation and open water is important for common moorhens on the mainland (presumably also for the Hawaiian subspecies), optimally with an overall ratio of 50:50 (Weller and Fredrickson 1973).

HAWAIIAN STILT or ae'o (*Himantopus mexicanus knudseni*)

Taxonomy

The Hawaiian stilt (*Himantopus mexicanus knudseni*) or ae'o is part of a cosmopolitan superspecies complex comprising the black-necked stilt (*Himantopus mexicanus*) of North and South America, the black-winged stilt (*H. himantopus*) of Eurasia and Africa, and the pied stilt (*H. leucocephalus*) and the black stilt (*H. novaezelandiae*) from Australasia. The Hawaiian stilt is clearly allied with the black-necked stilt and is considered a distinct subspecies (American Ornithologists' Union 1983). However, some behavioral and morphological evidence suggests the Hawaiian stilt is a distinct species. Genetic analysis is being conducted to assess species relationships (Robert Fleischer, personal communication 1993). Colonization of Hawaii by stilts probably resulted from North American vagrants.

Species Description

The stilt is a slender wading bird, black above (except for the forehead), white below and with distinctive long, pink legs. The Hawaiian stilt differs from the black-necked stilt by having black extending lower on the forehead as well as around to the sides of the neck, and by having a longer bill, tarsus (leg), and tail (Coleman 1981). Sexes are distinguished by the color of the back feathers (brownish female, black male) as well as by voice (females having a lower voice). Downy chicks are well camouflaged, tan with black speckling. Immatures have a brownish back, and white patches on their cheeks (Pratt *et al.* 1987). Immature birds produce a sharp peeping call. The total length of adult Hawaiian stilts is about 40 centimeters (16 inches).

Historical Range and Population Status

Stilts were historically known from all of the major islands except Lanai, Kahoolawe, and possibly the island of Hawaii (Paton and Scott 1985). There are no documented records of Hawaiian stilt on the island of Hawaii prior to 1961 (Paton and Scott 1985). As with the other Hawaiian waterbirds, estimates of historic numbers are undocumented. However, extensive wetlands and aquatic agricultural lands provided a sizable amount of habitat. Loss of this habitat undoubtedly caused a decrease in stilt numbers. It has been suggested that the population had declined to approximately 200 birds by the early 1940's (Munro

1960). This number, however, may have been an underestimation of the population, as other estimates from the late 1940's place the population at approximately 1,000 birds (Schwartz and Schwartz 1949). This may still be a low estimate, as a sizable number of stilts can seasonally be found on Niihau which was not surveyed in the 1940's. The Hawaiian stilt was a popular game bird, and hunting contributed to local population declines until waterbird hunting was prohibited in 1939 (Schwartz and Schwartz 1949).

Current Range and Population Status

Stilts are now found on all of the main Hawaiian Islands except Kahoolawe (Figure 5). The first stilts on Lanai were documented in 1989 at the Lanai City wastewater treatment ponds (M. Ueoka, State Department of Land and Natural Resources, personal communication 1993). Long-term census data indicate that statewide populations have been relatively stable or slightly increasing for the last 30 years (Reed and Oring 1993). From 1983 to 1996, statewide surveys documented 1,500 or more stilts in the state (State Department of Land and Natural Resources waterbird surveys 1983 to 1996, Appendix C4). Recent estimates place the population at approximately 1,200 to 1,600 birds (Griffin *et al.* 1989, Engilis and Pratt 1993). As with coots, census data show high year-to-year variability in the number of stilts observed (Appendix C4). This variability can be partially explained by rainfall patterns and reproductive success (Engilis and Pratt 1993). Hawaiian stilts readily disperse between islands and constitute a homogeneous metapopulation (Reed *et al.*1994, Reed *et al.*1998).

Kauai and Niihau Populations

The stilt population annually moves between these two islands apparently in response to rainfall patterns and the flooding and drying of Niihau's ephemeral lakes (Engilis and Pratt 1993). On Kauai, stilts are numerous in large river valleys such as Hanalei, Wailua, and Lumahai; and on the Mana Plain. Stilts also frequent Kauai's reservoirs, particularly during drawdown periods, as well as sugarcane effluent ponds in Lihue and Waimea.

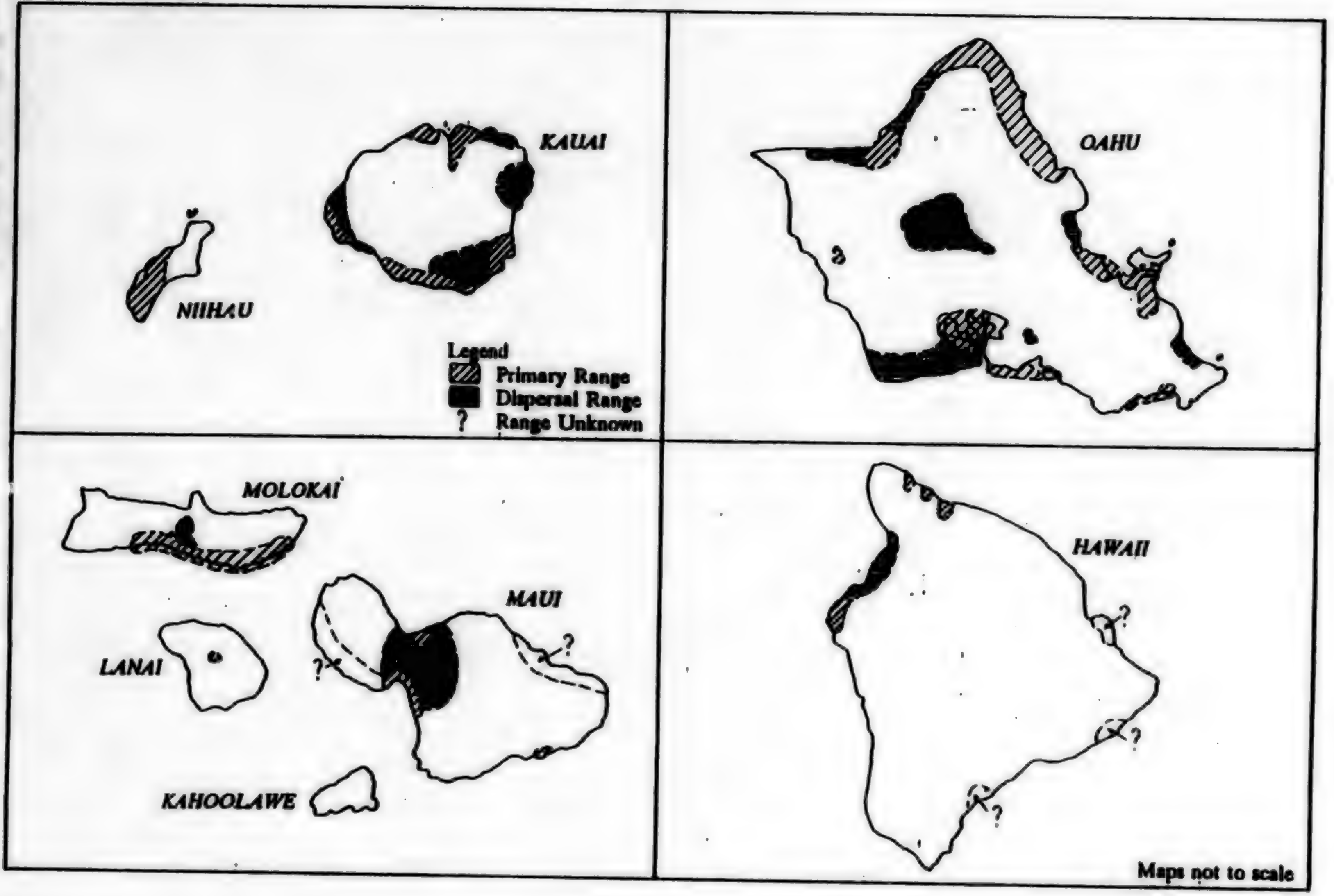

Figure 5. Known distribution of Hawaiian stilt in the Hawaiian Islands.

Oahu Population

Oahu supports the largest number of stilts in the Hawaiian Islands (Engilis 1988). The majority of Oahu's stilts can be found on the north and windward coasts, primarily on Kahuku Point (James Campbell National Wildlife Refuge, Kahuku Point oyster ponds, Amorient aquaculture ponds, and Roland Pond), and on Nuupia Ponds in Kaneohe. Isolated populations also exist in Pearl Harbor and along the leeward coast. Census data show a decrease in the number of stilts on Oahu during the mid-1960's, but an increase since 1968 (Reed and Oring 1993). From 1977 to 1996, Oahu averaged between 40 to 60 percent of the State stilt population (Engilis 1988, State Department of Land and Natural Resources waterbird survey data 1989 to 1996).

Maui, Molokai, and Lanai (Maui Nui) Populations

Maui's two large coastal wetlands, Kanaha and Kealia, support a significant number of Hawaiian stilt, with important nesting habitat at Kealia. Monthly counts indicate that birds freely move between these two wetlands, apparently in search of optimal foraging habitat (Ueoka 1979). Stilt numbers on Maui have ranged between 200 and 500 birds since 1983. Stilt also frequent reservoirs and aquaculture areas on Maui, but not in significant numbers.

Molokai's south coast wetlands and playa lakes are, at times, important habitats for stilts. There is some evidence of periodic movements of birds between Maui and Molokai, again probably in response to available foraging habitat (Engilis and Pratt 1993). Since 1968, statewide waterbird surveys show a significant increase in birds on Molokai (Reed and Oring 1993). Comprehensive surveys on Molokai place the island's population around 125 birds (Ducks Unlimited surveys 1993 to 1995).

Hawaiian stilts are now permanent residents at the Lanai City wastewater treatment ponds. They have been recorded annually since the ponds became operational in 1989 and now exceed 30 birds (State Department of Land and Natural Resources waterbird survey records 1989 to 1996).

Hawaii Island Population

As mentioned previously, there are no substantiated records of stilt on the Big Island prior to 1961. The Kona Coast from Kawaihai Harbor south to Kailua, supports the largest number of stilts on the Big Island, with Makalawena and Aimakapa Ponds being key breeding areas. Additionally, stilts have become numerous on the Cyanotech Ponds and Kona wastewater treatment ponds. The species can be found along the Hamakua Coast and in the Kohala River valleys of

Waipio, Waimanu and Pololu. The scattered anchialine ponds (land-locked brackish-water pools adjacent to the ocean, lacking surface connection to the ocean but with a subterranean connection to the ocean and showing a damping tidal fluctuation in water level) along the Kona Coast are important feeding sites. Comprehensive surveys on Hawaii have placed the Kona Coast population at 130 birds (Ducks Unlimited surveys 1996 to 1997).

Life History

Stilts prefer to nest on freshly exposed mudflats, interspersed with low growing vegetation. The nest itself is a simple scrape on the ground. They have also been observed using grass stems and rocks for nesting material (M. Morin, personal communication 1994). Nesting also occurs on islands (natural and manmade) in fresh or brackish ponds (Shallenberger 1977). Higher nesting densities are found on large mudflat expanses interspersed with vegetation (U.S. Fish and Wildlife Service 1983b). On Kauai, stilts have also been observed successfully using manmade floating nest structures (T. Telfer, personal communication 1988). Stilts defend an area 20 to 30 meters (66 to 99 feet) around the nest and are semicolonial.

The nesting season normally extends from March through August, and peaks in May and June. Stilts usually lay 3 to 4 eggs that are incubated for approximately 24 days (Coleman 1981, Chang 1990). Chicks are precocial, leaving the nest within 24 hours of hatching. Young may remain with both parents for several months after hatching (Coleman 1981).

A hatching success of 54 percent (243 nests, 833 eggs) was reported from Kii Unit of the James Campbell National Wildlife Refuge (Chang 1990). Of the total nests observed at Kii (243), 61 were lost to predation and 42 were lost to flooding or abandonment (Chang 1990). Because of their exposed nest sites, stilts appear to be more susceptible to avian predators than other Hawaiian waterbirds.

Stilts are opportunistic feeders. They eat a wide variety of invertebrates and other aquatic organisms as they are available in shallow water and mudflats. Specific organisms taken include polychaete worms, small crabs, aquatic insects, and small fish (Shallenberger 1977).

Feeding typically occurs on shallowly flooded wetlands. These types of wetlands are ephemeral in nature and may appear at any time of the year, but primarily in winter. Intraisland movement has been suggested as an important strategy for exploiting food resources and has been well documented on Oahu

(Michael Reed, University of Nevada-Reno, personal communication 1993) and Maui (Ueoka 1979). Annual interisland movements are also supported by statewide waterbird survey data (Engilis and Pratt 1993).

Habitat Description

Stilts use a variety of aquatic habitats but are limited by water depth and vegetation cover. Stilts require early successional marshlands with water depth less than 24 centimeters (9 inches), perennial vegetation that is limited and low growing (*Paspalum* and *Batis*), or exposed tidal flats. They rarely occur in wetlands above 200 meters (660 feet) elevation. Ephemeral lakes on Molokai, Maui, and Niihau are important for stilts. We have recently adopted management techniques at the Hanalei National Wildlife Refuge that mimic seasonal inundation and evaporation of freshwater mudflats. Insular mudflats are isolated from terrestrial predators, but are still susceptible to avian predation. On the island of Hawaii, anchialine ponds provide important foraging habitat for the Hawaiian stilt. Prawn farms, which have numerous ponds in perpetual drawdown and flood-up, provide excellent foraging habitat for adult birds.

Stilts generally forage and nest in different wetland sites, moving between these areas daily. Adults with 3 day old chicks have been observed to move 0.5 kilometers (0.3 miles) from the nest site (Reed and Oring 1993). Nesting sites are adjacent to or on low-relief islands within bodies of fresh, brackish, or salt water. These bodies of water include irrigation reservoirs and settling basins, natural or manmade ponds, marshes, taro patches, silted ancient fish ponds, salt evaporation pans, and other wetlands.

Feeding habitat consists of shallow water that is fresh, brackish, or saline. The freshwater sites include irrigation reservoirs and settling basins and natural or manmade ponds, including taro patches and sewage oxidation ponds, sugar settling basins, and marshes. Brackish water feeding habitat consists of some coastal ponds, silted ancient fish ponds, and estuaries. Saltwater feeding habitat includes inshore reefs, silted beach areas, and tidal flats.

Loafing areas are generally open mudflats, *Batis* flats, or open pasture lands where visibility is good and predator populations are low or accessibility is poor.

3. Reasons for Decline and Current Threats

The primary cause of the decline of the four species of endangered Hawaiian waterbirds has been the loss of wetland habitat. Hunting in the late 1800's and early 1900's took a heavy toll on koloa populations and, to a lesser extent, populations of the other three endemic waterbirds (Swedberg 1967). Other factors that contributed to historic waterbird population declines, which continue to be detrimental, include predation by introduced animals, altered hydrology, invasion of habitat by alien plants, hybridization, disease, and possibly environmental contaminants.

Loss of Wetland Habitat

A significant amount of Hawaii's wetlands have been filled or otherwise modified and are now occupied by hotels, housing developments, golf courses, shopping centers, landfills, military installations, highways, former sugarcane fields, and industrial sites. Hawaii contains approximately 44,320 hectares (110,800 acres) of wetlands and deep water habitats, of which 81 percent are classified as palustrine scrub-shrub forest habitats (not utilized by Hawaii's four endangered waterbirds). This class is located at mid- to high elevations and occurs as bogs and rainforest ecosystems. We estimated that 8,990 hectares (22,475 acres) of wetlands existed within coastal plains of Hawaii circa 1780 (U.S. Fish and Wildlife Service 1990). In 1990, we estimated 6,190 hectares (15,474 acres) remaining, a decrease of 31 percent (Dahl 1990).

Wetland agriculture (taro, lotus, and rice) has provided managed wetlands for waterbirds since the arrival of the first Polynesians (Stone 1989). As early as the 1850's, significant losses of this type of habitat began with the partial replacement of taro by other agricultural crops (e.g., sugarcane) and by development for an expanding industrial society (Bostwick 1982). This gradual process has continued into the 20th century. Sugar plantations provided a limited amount of habitat via settling basins and reservoirs. The collapse of the sugar cane industry has resulted in draining of many of these reservoirs and sugar settling basins. Both habitats were widely utilized by resident waterbirds, migratory waterfowl, and shorebirds.

Many waterbirds have become dependent upon aquaculture wetlands for their survival (Engilis and Pratt 1993). In Hawaii, this industry reached its peak in the mid-1980's and is now declining. The instability of the aquaculture industry does not provide secure, long-term habitat for waterbirds.

Waterbirds are occasionally implicated as a cause of depredation in taro and prawn farms. This may result in efforts by farmers to place exclusion devices around ponds that would effectively eliminate some habitat presently utilized.

Many of Hawaii's wetlands that were once surrounded by open space are becoming more urban. This is a trend which raises concerns regarding human disturbance, water quality (from urban runoff), and an increased incidence of cats and dogs on wildlife areas (Brown and Dinsmore 1986, Reid 1993). Development pressure in wetland areas has been most prevalent on the islands of Oahu and Maui. Urban development has encroached or will soon be encroaching upon both Kanaha and Kealia Ponds on Maui. The Honouliuli Unit of Pearl Harbor National Wildlife Refuge and James Campbell National Wildlife Refuge are both being surrounded by urban development. The continued expansion of hotels and golf courses on the Kahuku Plain, Oahu, will eliminate waterbird use of ephemeral wetlands that are lost to development.

Hunting

Indiscriminate hunting of migratory waterfowl in the late 1800's and early 1900's took a heavy toll on koloa populations. During this time, while habitat size and quality decreased, direct pressure on the bird populations increased. When bag limits were introduced, they were generous (25 ducks of all kinds per day during a 4-month season) and difficult to enforce. In 1925, the Territorial Fish and Game Commission closed the koloa season, but because of the koloa's similarity to female mallard and pintails, koloa probably received little protection (Swedberg 1967). A total ban on waterfowl hunting in 1939, still in effect today, provided important protection for the remaining koloa (Bostwick 1982). Continued hunting of coots, moorhens, and stilts probably affected local populations prior to 1939.

Introduced Predators

Introduction of mammalian predators has had a negative impact on all populations of waterbirds (Griffin *et al.* 1989). Mongooses were first introduced to the Big Island in 1883 and subsequently to Maui, Molokai, and Oahu. Mongooses have become a serious threat to waterbirds throughout these islands (Tomich 1969), taking eggs, young birds, and nesting adults. Feral cats became established in Hawaii shortly after European contact and were common in Oahu forests as early as 1892 (Tomich 1969). Cats range from sea level to at least 2,150 meters (7,095 feet) on the Big Island. Dogs have become a serious problem on many wetlands adjacent to urban areas. Koloa on Oahu are particularly susceptible to predation by dogs (Chang 1990). Rats may also have a negative effect on waterbirds.

Other introduced species, such as the cattle egret (*Bulbulcus ibis*), bullfrog (*Rana catesbeiana*) and barn owl (*Tyto alba*), also have had a negative impact on the waterbirds. Cattle egrets may play an undetermined role as a predator of nestling birds. The introduced bullfrog is known to eat young koloa ducklings (Ron Walker, State Department of Land and Natural Resources, personal communication 1982). Barn owls have been observed taking adult stilt and are presumed to take chicks as well (Kathleen Viernes, U.S. Fish and Wildlife Service, personal communication 1994).

The problems posed by these predators are magnified by a severe shortage of protected nesting areas. The importance of core wetland areas to the continued survival of waterbirds is most evident during drought periods when waterbird populations become concentrated. Nesting, foraging, and loafing sites become a premium and overcrowding can result. Predator numbers rapidly increase in response to this increased food source. This type of predator response has been well documented in North America and is summarized by Sargeant and Raveling (1992).

Altered Hydrology

Unless managed specifically for waterbirds, altering the hydrology of wetland areas makes them less suitable or unusable for native waterbirds. These types of alterations include modifications made for flood control and municipal water sources. Water depths as well as the timing of water level fluctuations differ from those occurring naturally and Hawaii's waterbirds cannot adjust their breeding behavior to minimize impacts to their reproductive effort. This problem exists for several wetland areas in Hawaii. Depleted freshwater aquifers can facilitate salt water intrusion into coastal ground water supplies, resulting in altered salinity levels in associated wetlands.

Invasion of Habitat by Alien Plants

The alteration of wetland plant communities due to invasion by nonnative plants can greatly reduce the usefulness of wetland areas to native waterbirds. In fact, this remains the main problem facing wetland managers in the State. Managers are constantly faced with developing techniques and then securing enough staff and management funds to implement practices. Species such as California grass (*Brachiaria mutica*), pickleweed (*Batis maritima*), water hyacinth (*Eichornia crassipes*), Indian fleabane (*Pluchea indica*), and mangrove (*Rhizophora mangle*) present serious problems in most Hawaiian wetlands by out-competing more desirable species and eliminating open water, exposed mudflats, or shallows (Shallenberger 1977). For example, Kawainui Marsh on Oahu, with a total area of 300 hectares (750 acres), has only 20 to 40 hectares (50 to 100 acres) of open water. Ukoa and Heeia Marshes on the same island are also 80 to 90 percent overgrown.

Hybridization

An important threat specifically affecting koloa is the danger of genetic introgression through interbreeding with feral mallards. The problem of hybridization is most critical on Oahu where the majority of koloa are hybrids (Browne *et al.* 1993). Kauai and Hawaii's populations of koloa still remain genetically isolated from mallards, but the existence of domestic and feral mallards on both islands presents a serious threat (Engilis and Pratt 1993). The reduction in wetland habitat increases opportunities for hybridization as populations are forced to share smaller areas.

Avian Disease

Avian disease can impact local waterbird populations. The most prevalent avian disease affecting Hawaii's waterbirds is botulism, which has been recorded on Kauai, Oahu, Maui, and Hawaii. The disease is of annual occurrence and affects all native and migratory waterbirds. Botulism is a recurrent problem on Hanalei National Wildlife Refuge and Aimakapa Pond, Hawaii.

Environmental Contaminants

Environmental contaminants in coastal wetlands are a concern because the general diet of these birds makes them susceptible to toxins accumulated within the food chain. In 1988, a fuel spill in Pearl Harbor caused direct mortality and nest abandonment of native waterbirds at the Honouliuli Unit of Pearl Harbor National Wildlife Refuge (Jerry Leinecke, U.S. Fish and Wildlife Service, personal communication 1993). In 1995, an oil spill in Pearl Harbor jeopardized Hawaiian stilt as well as marine fisheries.

4. Conservation Measures

Conservation efforts have included a long-term hunting ban, protection of habitat through establishment and management of refuges and sanctuaries (Table 1 and Appendix B), population monitoring, numerous research projects, the release of captive-bred koloa, and restrictions on the importation of mallards.

Federal Actions

The koloa and moorhen were declared federally endangered species in 1967 (U.S. Fish and Wildlife Service 1967). The Hawaiian coot and stilt were added to the Federal endangered species list in 1970 (U.S. Fish and Wildlife Service 1970).

The following wetland habitat areas are under Federal jurisdiction:

Huleia National Wildlife Refuge - In 1973, Huleia National Wildlife Refuge, including 95 hectares (238 acres) of river bottom habitat, was established on Kauai, south of the town of Lihue. We have begun development of habitat on the refuge through taro farming activities.

Hanalei National Wildlife Refuge - The first National Wildlife Refuge for waterbirds in Hawaii, consisting of 367 hectares (917 acres), was acquired in Hanalei Valley, on Kauai, in 1972. Habitat management and restoration are ongoing on the refuge.

James Campbell National Wildlife Refuge has become one of the State's most important waterbird refuges. The refuge size (57 hectares (142 acres)), management, and remoteness all contribute to its importance. The land is currently only leased to the Fish and Wildlife Service and secure protection is needed. The permanent wetlands of the site are supported by numerous seasonal wetlands not currently within refuge boundaries. We have a unique opportunity here, through additional protection, to protect a critical wetland system that supports waterbirds throughout their annual cycle, thus maintaining dispersal patterns for all species.

Pearl Harbor National Wildlife Refuge - This Refuge, composed of two manmade wetland units (Waiawa and Honouliuli) totaling 24.5 hectares (61 acres), was established by a cooperative agreement with the U.S. Navy in 1976.

Table 1. Secured wetland habitats in the Hawaiian Islands, January 1994.

WETLAND	ACRES	HECTARES	RESPONSIBILITY	STATUS
Kauai Totals	**1175**	**470**		
Mana Base Ponds	5	2	Private/DLNR	Managed
Kawaiele Ponds	15	6	DLNR	Restoration Ongoing
Huleia NWR	238	95	USFWS	Restoration & Management needed
Hanalei NWR	917	367	USFWS	Managed
Oahu Totals	**1748**	**701**		
Kawainui Marsh	750	300	DLNR	Restoration & Management needed
Heeia Marsh	400	160	DLNR	Restoration & Management needed
Hamakua Marsh	23	9	DLNR	Restoration Ongoing
Paiko Lagoon Wildlife Sanctuary	25	10	DLNR	Managed
Pouhala Marsh	70	28	DLNR/County	Restoration & Management needed
James Campbell NWR	142	57	Private/USFWS	Managed
Pearl Harbor NWR	61	25	USFWS	Managed
Nuupia Ponds	237	96	USMC	Managed
Lualualei	40	16	USN, USFWS	Managed

Table 1. Continued.

WETLAND	ACRES	HECTARES	RESPONSIBILITY	STATUS
Maui/Molokai Totals	**708**	**285**		
Kanaha Pond Sanctuary	143	57	DLNR	Managed
Kealia Pond NWR	500	200	USFWS	Restoration & Management needed
Ohiapilo Wetland	25	10	Maui County	Restoration and Management needed
Kakahaia NWR	40	16	USFWS	Management needed
Hawaii Totals	**75**	**30**		
Aimakapa/Kaloko	55	22	NPS	Managed
Parker Ranch Ponds	20	18	Private/DU	Managed

Abbreviations: DLNR = State Department of Land and Natural Resources, DU = Ducks Unlimited, NPS = National Park Service, NWR = National Wildlife Refuge, USFWS = U.S. Fish and Wildlife Service, USMC = U.S. Marine Corps, USN = U.S. Navy.

Nuupia Ponds - A tri-agency cooperative agreement exists with the U.S. Marine Corps, the U.S. Fish and Wildlife Service, and the State Department of Land and Natural Resources, for the management of this wetland area. There are eight shallow mixohaline ponds (brackish waters resulting from a mix of fresh and ocean water), totaling about 96 hectares (237 acres), that make up the Nuupia Pond complex on the Kaneohe Marine Corps Air Station on the east side of Oahu. The open water and extensive mudflats with stands of pickleweed provide valuable habitat for Hawaiian stilts. Under contract with the U.S. Marine Corps, we completed an update to the Fish and Wildlife Management Plan for Marine Corps Air Station Kaneohe Bay. The U.S. Marine Corps have enacted a management program for these wetlands.

Lualualei - Located on Oahu's leeward coast, Lualualei was formerly a water storage reservoir. The existing basin is choked with California grass, but continues to hold water after heavy run-off. The reservoir provides marginal habitat but presents some opportunity for enhancement. This 16 hectare (40 acre) wetland on U.S. Navy property is managed under a cooperative agreement between the Navy and the U.S. Fish and Wildlife Service.

Kealia Pond National Wildlife Refuge - A very important 200 hectare (500 acre) wetland and pond is located near Kihei. It provides valuable nesting, loafing, and feeding habitat for stilts and coots. It was acquired in 1993 and established as a National Wildlife Refuge. The U.S. Fish and Wildlife Service and Ducks Unlimited are currently developing a restoration and management plan that will improve habitat for waterbirds, provide secure water delivery to restored ponds, and provide for public use activities (e.g. wildlife viewing and education).

Aimakapa/Kaloko - This is about 10 hectares (25 acres) of open water and another 8 hectares (20 acres) of marsh. The surrounding region is becoming developed. Aimakapa Pond is the most important Kona Coast wetland supporting most of the coots and stilts in the region. The National Park Service acquired these ponds as part of Kaloko-Honokohau National Historic Park. The National Park Service is currently monitoring bird use on the marsh, however, management plans emphasize the restoration of the area as a demonstration fishpond for cultural resource preservation.

Kakahaia National Wildlife Refuge - In 1976 Kakahaia National Wildlife Refuge, 18 hectares (45 acres) of pond and kiawe (*Prosopis pallida*) woodland, was established on Molokai's south shore.

In 1975, we established the Hawaiian Waterbird Recovery Team. The mission of this team was to evaluate available data and develop a plan for the recovery of the Hawaiian stilt, coot, and moorhen (the koloa was not included in this first plan). The Hawaiian Waterbirds Recovery Plan was completed in 1978 (U.S. Fish and Wildlife Service 1978). The primary objective of this first plan, as defined by the Team, was to maintain at least 2,000 birds of each species within the distributions and habitats recorded in 1976. Upon accomplishment of these objectives, downlisting and then delisting the waterbirds could be considered. The plan was revised and updated in 1985 to include the koloa (U.S. Fish and Wildlife Service 1985).

State Actions

A century ago, most of Hawaii's endemic and migratory waterbirds had some legal protection because of their suspected role in the control of army worms. Yet, all species continued to be hunted for several more decades. Hunting for koloa was closed on Kauai in 1925, but hunting for other species and for koloa on the other islands continued until 1939.

After World War II, State biologists, with Federal assistance, began an investigation of migratory waterfowl in the belief that wintering populations might support a continued hunting program. Although waterbird hunting was never reopened, this early study became the foundation of a continuing program of semiannual statewide waterfowl surveys, which was expanded to include all endemic waterbirds. Semiannual counts of waterbirds have been conducted statewide since 1975. Data from these surveys has been used to monitor population trends.

Captive propagation and release of koloa on the islands of Oahu and Hawaii was conducted from 1958 to 1982 by the State of Hawaii.

The State has responsibility for the following wetland habitat areas:

Mana Base Pond - State and private landowners manage this 2 hectare (5 acre) site in the Kekaha region of Kauai.

Kawaiele Ponds - The State, through a sand mining lease, has created several ponds totaling 8 hectares (20 acres). The Kawaiele Ponds have been sculpted to provide nest islands, sloped banks, and water depths suitable for all four endangered waterbirds. The area is a State wildlife sanctuary.

Kawainui Marsh - Historically, this 300 hectare- (750 acre-) marsh on windward Oahu contained a 180 hectare- (450 acre-) fishpond used by native Hawaiians. It is fed primarily by Maunawili and Kahanaiki streams. The marsh eventually feeds into a canal and into Kailua Bay. Most of the marsh is densely vegetated; however, some open water exists near the center. Expansion of open water areas would facilitate use by all four waterbirds, which now use the area in small numbers. Kawainui Marsh is currently owned by the Department of Land and Natural Resources (76 hectares around periphery; 190 acres) and the City and County of Honolulu (the remaining 224 hectares; 554 acres). The entire area is managed by the State of Hawaii. In 1993, the State began extensive planning efforts for wetlands restoration, habitat development, and long-term management.

Heeia Marsh - This 160 hectare (400 acre) area was formerly a complex of tidal marshes and open water areas. It has been substantially modified and presently consists of alien mangroves, remnants of ponds, and wet pasture grazed by cattle. This wetland area should be restored and managed to provide enhanced habitat for all four waterbirds. The State has secured this property through a land exchange that was completed in 1992. The State Department of Land and Natural Resources is currently planning for enhancement and management of the upland and wetland resources.

Hamakua Marsh - Hamakua Marsh is a 9 hectare (23 acre) wetland associated with Kawainui Marsh. Located along Hamakua Drive in Kailua, it is utilized by all four species of waterbirds and has been secured by Ducks Unlimited, who donated the land to the State Department of Land and Natural Resources. The site has been restored but requires additional enhancement actions to improve habitat for native waterbirds.

Paiko Lagoon Wildlife Sanctuary - In 1969, the State established this 10 hectare (25 acre) tidal flat as a wetland sanctuary on Oahu's south shore. This tidal flat is important for migratory shorebirds and is frequented at low tide by several stilts.

Pouhala Marsh - Owned by the State and City and County of Honolulu, this tidal marsh in Pearl Harbor has been modified and partially filled. Trespass, litter, and human disturbance are still problems. The State has control of this wetland and is developing plans in cooperation with the Fish and Wildlife Service and Ducks Unlimited to clean and restore the site.

Kanaha Pond Sanctuary - In 1952, Kanaha Pond, a 57 hectare (143 acre) wetland on Maui, was designated as the first State wetland sanctuary. This wetland is owned by the State Department of Transportation and managed by the State Department of Land and Natural Resources.

Federal and State Actions

State and Federal efforts have now protected 1,448 hectares (3,616 acres) or 23 percent of the remaining 6,190 hectares (15,475 acres) of coastal wetlands. Table 1 summarizes protected wetland areas by island. In 1964, the Fish and Wildlife Service (then Bureau of Sport Fisheries and Wildlife) and the State Department of Land and Natural Resources became directly involved in studies of Hawaiian stilts and other waterbirds at Kanaha Pond.

An assessment of wetland habitats for endangered waterbirds was jointly published by State and Federal biologists in 1970, followed by an important summary of the status of Hawaii's wetlands (Shallenberger 1977).

Private Actions

Serious research on endemic waterbirds began in 1962 with a World Wildlife Fund-supported study of the koloa on Kauai. From 1980 to the present, research has been conducted to improve biological knowledge of Hawaii's endangered waterbirds (Coleman 1981, Nagata 1983, Griffin *et al.* 1989, Chang 1990, Engilis and Pratt 1993, Browne *et al.* 1993, Reed and Oring 1993, Reed *et al.* 1994, Reed *et al.* 1998).

Ducks Unlimited, a private wetlands conservation organization, works cooperatively with State and Federal agencies as well as with private landowners and local corporations on wetlands conservation, habitat restoration, and protection efforts. In 1997, Ducks Unlimited developed a comprehensive, cooperative plan to protect and restore wetlands utilized by native waterbirds. Ducks Unlimited has signed a Memorandum of Understanding with the Natural Resources Conservation Service to undertake Wetlands Reserve Program projects statewide. Ducks Unlimited has also developed a cooperative position with the U. S. Fish and Wildlife Service for a dedicated wetlands staff person to undertake and coordinate wetlands programs statewide. Ducks Unlimited is also developing a coastal wetlands data base and habitat restoration model (A. Engilis, personal communication 1998).

5. General Recovery Strategy

The plan for recovery of Hawaii's four endangered waterbirds involves a number of levels of protection for important habitat areas. Some of the recommended actions are site-specific, such as establishing protected land status and writing management plans, while other actions such as population monitoring and public education should be implemented on a statewide basis. The basic steps detailed in this plan are as follows:

1) Protect and actively manage wetland habitat areas in order to maximize productivity and survival of endangered waterbirds. This management would include the following: develop written management plans, manage water levels, manage vegetation, control predation, monitor waterbird populations, remove the threat of mallard-koloa hybridization, minimize human disturbance, as well as monitor and control avian diseases and environmental contaminants (Table 2). Some of these wetland habitat areas already have protected status, but need to be actively managed.

2) Establish moorhen populations on two additional islands and koloa on one additional island.

3) Conduct research to better define limiting factors, determine recovery objectives, and improve management techniques.

4) Conduct an information and education program to increase public support.

5) Validate recovery objectives.

Table 2. Specific recovery actions recommended for protected wetland habitats and additional primary wetland habitat areas. (as discussed in section II. 3. Step-down Narrative)

WETLAND	STATUS			RECOMMENDED RECOVERY ACTIONS								
	Hectares (Acres)	Responsibility	Protected	12	121	122	123	124	125	126	127	13
NIIHAU												
Playa Lakes	760 (1900)	Private	No	X			X		X	X		
KAUAI												
Hanalei NWR	367 (917)	USFWS	Yes	X	X	X	X	X	X	X	X	X
Huleia NWR	95 (238)	USFWS	Yes	X	X	X	X	X	X	X		X
Kawaiele Ponds	6 (15)	DLNR	Yes	X		X		X	X	X	X	X
Lumahai Valley	50 (125)	Private	Nes	X		X	X	X				X
Mana Base Ponds	2 (5)	Pvt/DLNR	Yes	X		X	X	X				X
Mana Wetlands	81 (200)	Pvt/State	No	X			X	X	X			X
Opaekaa Marsh	20 (50)	Pvt/DLNR	No	X	X	X	X	X	X	X		X
OAHU												
Amorient prawn farm	40 (100)	Private	No	X	X	X	X	X	X	X	X	X
Hamakua Marsh	9 (23)	DLNR/DU	Yes	X	X	X	X	X	X	X	X	X

Table 2. Continued.

WETLAND	STATUS			RECOMMENDED RECOVERY ACTIONS								
	Hectares (Acres)	Responsibility	Protected	12	121	122	123	124	125	126	127	13
Heeia Marsh	160 (400)	DLNR	Yes	X	X	X	X	X	X	X		X
James Campbell NWR	57 (142)	USFWS	Yes	X	X	X	X	X	X	X	X	X
Kawainui Marsh	300 (750)	DLNR	Yes	X	X	X	X	X	X		X	X
Laie Wetlands	80 (200)	Private	No	X								X
Lualualei Reservoir	16 (40)	USN/USFWS	Yes	X	X	X	X	X	X	X	X	X
Nuupia Ponds	96 (237)	USMC	Yes			X		X	X		X	X
Paiko Lagoon	10 (25)	DLNR	Yes	X	X	X	X	X	X	X	X	X
Pearl Harbor NWR	25 (61)	USFWS	Yes	X		X	X	X	X	X	X	X
Pouhala Marsh	10 (25)	DLNR	Yes	X		X	X	X	X		X	X
Punahoolapa Marsh	40 (100)	Private	No	X	X	X	X	X	X	X	X	X
Ukoa Marsh	120 (300)	Private	No				X	X	X			X
Waialua Lotus Fields	*	Private	No	X	X	X	X	X	X			X
Waihee Marsh	10 (25)	Federal	No	X	X	X	X	X	X			X
Waipio Peninsula Ponds	*	USFWS/USN	No	X		X	X	X	X	X	X	X
MAUI												

Table 2. Continued.

WETLAND	STATUS			RECOMMENDED RECOVERY ACTIONS								
	Hectares (Acres)	Responsibility	Protected	12	121	122	123	124	125	126	127	13
Kanaha Pond	57 (143)	DLNR	Yes	X	X	X	X	X	X	X	X	X
Kealia Pond NWR	(700)	USFWS	Yes	X	X	X	X	X	X	X	X	X
MOLOKAI												
Kakahaia NWR	16 (40)	USFWS	Yes	X	X	X	X	X	X	X		X
Ooia-Kaluaapuhi Ponds	*	Private	No	X	X	X	X	X	X	X		X
Paialoa	2 (5)	Private	No	X		X	X	X	X			X
HAWAII												
Aimakapa/Kaloko Pond	22 (55)	NPS	Yes		X	X	X	X	X	X		
Loko Waka	*	Pvt/State	No	X	X	X	X	X	X		X	X
Waiakea	*	County	Yes	X	X	X	X	X	X	X	X	X
Montane Stock Ponds	*	Private	No	X	X	X	X	X	X			
Parker Ranch Ponds	18 (45)	Private	Yes	X	X	X	X	X	X			
Opaeula Ponds	3 (7.5)	Private	No	X	X	X	X	X	X			

Key: USFWS = U.S. Fish and Wildlife Service; NPS = National Park Service;
DLNR = Department of Land and Natural Resources; USN = U.S. Navy;
USMC = U.S. Marine Corps; Pvt = private; * = size undefined.

PART II. RECOVERY

1. Recovery Objectives

The objective of this recovery plan is to identify actions needed to downlist Hawaii's four endangered waterbirds from endangered to threatened status, and ultimately, to remove them completely from the Federal list of threatened and endangered species.

DEFINITIONS:

Endangered Species:	Any species which is in danger of extinction throughout all or a significant portion of its range.
Threatened Species:	Any species which is likely to become endangered within the foreseeable future throughout all or a significant portion of its range.

DOWNLISTING

The baseline population level for each species is based on current knowledge of population levels as revealed by State waterbird survey data from 1976 through 1996. For Hawaiian stilt, the population level is based on a population viability analysis determining carrying capacity based on current condition of habitat and other limiting and proximal factors (Reed *et al.* 1998). These population numbers will be used as starting points for establishment of recovery targets and are subject to revision based on future research and statistical analyses, as recommended in this revised recovery plan.

To downlist the four species to threatened status, the following criteria must be met:

Koloa maoli

a) The threat of hybridization with mallards is removed from all islands;

b) All wetlands listed in Table 1 on the islands of Kauai, Oahu, and Hawaii are protected and managed, following the management practices outlined in this plan;

c) Multiple, viable breeding populations are present on Kauai/Niihau, Oahu, and Hawaii; and

d) Statewide koloa population numbers show a stable or increasing trend, above a minimum of 2,000 birds, for at least 5 consecutive years.

Coot

a) The wetlands listed in Table 1 on the islands of Kauai/Niihau, Oahu, Hawaii, and Maui/Molokai are protected and managed, following the management practices outlined in this plan;

b) Multiple, viable breeding populations exist on Kauai/Niihau, Oahu, Hawaii, and Maui/Molokai; and

c) Statewide coot population numbers show a stable or increasing trend, above a minimum of 1,800 birds, for at least 5 consecutive years.

Moorhen

a) The wetlands listed in Table 1, on the islands of Kauai, Oahu, and either Maui/Molokai or Hawaii are protected and managed, following the management practices outlined in this plan;

b) Multiple, viable breeding populations exist on Kauai/Niihau, Oahu, and either Maui/Molokai or Hawaii; and

c) Statewide moorhen population numbers show a stable or increasing trend, above a minimum of 1,500 birds, for at least 5 consecutive years.

Stilt

a) The wetlands listed in Table 1 on the islands of Kauai/Niihau, Oahu, Hawaii, and Maui/Molokai are protected and managed, following the management practices outlined in this plan;

b) Multiple, viable breeding populations exist on Kauai/Niihau, Oahu, Hawaii, and Maui/Molokai; and

c) Statewide stilt population numbers show a stable or increasing trend, above a minimum of 1,500 birds, for at least 5 consecutive years.

DELISTING

To delist the four species, the following criteria must be met:

In addition to those areas that are already protected and managed (Table 1), the primary habitats listed below must be protected and managed for waterbirds, following the management practices outlined in this plan.

Niihau
- Playa Lakes

Kauai
- Opaekaa Marsh
- Mana Wetlands
- Lumahai Wetlands

Oahu
- Amorient prawn farms
- Laie Wetlands
- Ukoa Marsh
- Punahoolapa Marsh
- Waialua lotus fields
- Waihee Marsh
- Waipio Peninsula Ponds

Molokai
- Paialoa
- Ooia Playa-Fishponds

Hawaii
- Opaeula Pond
- Montane Stock Ponds
- Waiakea - Loko Waka Ponds

Species-specific delisting criteria:

Koloa maoli

a) The wetland areas specified for downlisting and the primary habitats listed above are protected and managed, following the management practices outlined in this plan;

b) Multiple, viable breeding populations exist on Kauai/Niihau, Oahu, Maui/Molokai, and Hawaii; and

c) Statewide koloa population numbers show a stable or increasing trend, above a minimum of 2,000 birds, for at least 10 consecutive years.

Coot

a) The wetland areas specified for downlisting and the primary habitats listed above are protected and managed, following the management practices outlined in this plan;

b) Multiple, viable breeding populations exist on Kauai/Niihau, Oahu, Maui/Molokai, and Hawaii; and

c) Statewide coot population numbers show a stable or increasing trend, above a minimum of 2,000 birds, for at least 10 consecutive years.

Moorhen

a) The wetland areas specified for downlisting, and the primary habitats listed above are protected and managed, following the management practices outlined in this plan;

b) Multiple, viable breeding populations exist on Kauai/Niihau, Oahu, Maui/Molokai, and Hawaii; and

c) Statewide moorhen population numbers show a stable or increasing trend, above a minimum of 2,000 birds, for at least 10 consecutive years.

Stilt

a) The wetland areas specified for downlisting, and the primary habitats listed above are protected and managed, following the management practices outlined in this plan;

b) Multiple, viable breeding populations exist on Kauai/Niihau, Oahu, Maui/Moloka,i and Hawaii; and

c) Statewide stilt population numbers show a stable or increasing trend, above a minimum of 2,000 birds, for at least 10 consecutive years.

2. Step-Down Outline

1. **Manage protected wetland habitats listed in Table 1.**
    - 11. **Develop management plans for protected wetland habitats listed in Table 1.**
    - 12. **Implement management plans for protected wetland habitats listed in Table 1.**
        - 121. **Manage water levels to maximize nesting success, brood survival, food availability, and recruitment.**
        - 122. **Manage vegetation to maximize nesting success, brood survival, food availability, and recruitment.**
            - 1221. Encourage desirable species.
            - 1222. Control noxious plants.
        - 123. Control predators.
            - 1231. Prevent predator access.
            - 1232. Eliminate or reduce populations of predators.
                - 12321. Control mongoose.
                - 12322. Control feral cats.
                - 12323. Control feral dogs.
                - 12324. Control rats.
                - 12325. Control cattle egrets.
            - 1233. Prevent introduction of new alien predators.
        - 124. Minimize human disturbance of waterbirds and their habitats.
            - 1241. Prevent intentional or accidental shooting of waterbirds.
            - 1242. Control access by people to sensitive habitats.

1243. Resolve conflicts resulting from actual or perceived depredation in aquaculture or agriculture developments by waterbirds.

1244. Minimize influence of urban encroachment.

125. Monitor all populations of endangered waterbirds.

1251. Develop adequate census techniques for Hawaii's endangered waterbirds.

1252. Continue semiannual, statewide surveys for all endangered waterbirds.

1253. Continue frequent surveys on protected wetlands.

1254. Monitor reproductive success on primary wetlands.

126. Monitor and control avian disease epidemics.

1261. Monitor waterbird populations to detect disease outbreaks as soon as possible.

1262. Take immediate action to restrict spread of disease outbreaks.

127. Minimize contamination of waterbird habitat by toxic substances.

1271. Monitor water quality.

1272. Restrict introduction of contaminants into wetland systems.

The following are additional management tasks needed to reach the downlisting objectives for koloa and moorhen.

13. Remove threat of mallard-koloa hybridization.

131. Implement statewide program to remove mallards and mallard-koloa hybrids.

1311. Conduct public information and education program regarding mallard-koloa interbreeding problem and need for the removal program.

1312. Develop methods for differentiating between koloa and mallard-koloa hybrids.

1313. Remove all mallards and mallard-koloa hybrids from all islands.

132. Ensure that new stocks of mallards and closely related ducks are not brought into the State.

14. Establish a population of moorhen on either Maui/Molokai or Hawaii.

141. Conduct thorough surveys of wetland areas on Maui, Molokai, and Hawaii to confirm that a population does not already exist.

142. If a population of moorhen is found on Maui, Molokai, or Hawaii, its wetland habitat should be protected and managed.

143. If no population of moorhen is found on Maui, Molokai, or Hawaii, sites for reintroduction of this species should be identified.

144. Investigate the pros and cons of captive propagation versus translocation.

145. Reintroduce either captive-bred or translocated moorhen to a protected and managed site on Maui, Molokai, or Hawaii.

2. Protect and manage additional primary habitats.

21. Provide long-term protection of additional primary wetland habitat areas that are not currently secured (listed below).

211. Protect Playa Lakes, Niihau.

212. Protect Opaekaa Marsh, Kauai.

213. Protect Mana Wetlands, Kauai.

214. Protect Lumahai Wetlands, Kauai.

215. Protect Amorient prawn farms, Oahu.

216. Protect Laie Wetlands, Oahu.

217. Protect Ukoa Marsh, Oahu.

218. Protect Punahoolapa Marsh, Oahu.

219. Protect Waialua lotus fields, Oahu.

2110. Protect Waihee Marsh, Oahu.

2111. Protect Waipio Peninsula Ponds, Oahu.

2112. Protect Paialoa, Molokai.

2113. Protect Ooia Playa-fish ponds, Molokai.

2114. Protect Opaeula Pond, Hawaii.

2115. Protect montane stock ponds, Hawaii.

2116. Protect Waiakea - Loko Waka Ponds, Hawaii.

22. Develop management plans for additional primary wetland habitat areas.

23. Implement management plans for additional primary wetland habitat areas.

Refer to tasks 121 through 127.

24. Coordination of watershed management plans.

25. Conduct interagency management workshops.

The following are additional management tasks needed to reach the delisting objectives for koloa and moorhen.

26. Establish a population of moorhen on either Maui/Molokai or Hawaii.

Refer to task 14.

27. Establish a population of koloa on Maui/Molokai.

    271. Conduct thorough surveys of wetland areas on Maui and Molokai to confirm that a population does not already exist.

    272. If a population of koloa is found on Maui or Molokai, its wetland habitat should be protected and managed.

    273. If no population of koloa is found on Maui or Molokai, sites for reintroduction of this species should be identified.

    274. Investigate the pros and cons of captive propagation versus translocation.

    275. Reintroduce either captive-bred or translocated koloa to a protected and managed site on Maui or Molokai.

3. Conduct research to better define limiting factors, determine recovery objectives, and improve management techniques.

31. Increase understanding of limiting factors.

    311. Conduct research on improved predator control methods.

    312. Conduct research on improved alien plant control methods.

    313. Conduct research on water sources for important wetlands.

    314. Determine the effects of avian predators on endangered waterbirds.

32. Conduct research to determine scientifically defensible recovery objectives.

    321. Conduct research on current population size, effective population size, and recent population trends.

    322. Conduct research on carrying capacity of available habitat.

    323. Conduct research on the sex and age structure of populations.

    324. Conduct research on reproductive parameters (age at first breeding, nest site and mate fidelity, length of nesting season, clutch size, hatching and fledging rates, nesting

attempts per pair, and total nesting attempts).

325. Conduct research on mortality rates.

326. Conduct research on inbreeding depression.

4. Conduct a public education and information program to increase public awareness and support for waterbird recovery.

41. Prepare and distribute television and radio spots, written information, slide programs, videos, films, posters, and displays.

42. Coordinate with the State Department of Education and private schools to incorporate wetland and waterbird information in school curricula. This could include field trips to waterbird refuges and sanctuaries.

43. Develop and maintain interpretive public displays of endangered waterbirds and wetlands.

5. Validate recovery objectives.

51. Conduct statistical analyses in order to determine minimum viable populations.

52. Revise recovery objectives.

3. Step-Down Narrative

1. Manage protected wetland habitats listed in Table 1.

A network of protected and managed wetland habitats is the key element in the recovery program for all four taxa. Loss of habitat has been and continues to be a prime threat, thus maintenance of productive habitat distributed over all the islands is imperative.

A number of wetland areas have been protected as waterbird habitat (Table 1). Some of these areas are sufficiently managed, but most of them need increased levels of management in order to maximize production and survivability.

Table 2 identifies the management needs and parties responsible for these protected wetlands as well as additional primary wetland habitat areas.

11. Develop management plans for protected wetland habitats listed in Table 1.

The acquisition or protection of refuges must be followed with an active planning process to identify management and habitat enhancement goals. The development of plans will help to obtain funding for restoration, provide for annual operations and maintenance budgets, and project management continuity when staff changes are made. Plans can be flexible and updated frequently as new methods are developed and incorporated into management schemes. See Table 2 for site-specific management recommendations as outlined by this plan.

12. Implement management plans for protected wetland habitats listed in Table 1.

Protected habitats, including National Wildlife Refuges, State sanctuaries, and private lands are some of the most important areas for waterbirds in Hawaii. Active management of these areas is required in order to realize their full potential for providing nesting and feeding habitat.

Table 2 identifies the management needs and parties responsible for the protected wetland habitats and additional primary wetland habitats. Management actions to be implemented on protected wetland habitats will include, but are not limited to, the following tasks.

Most wetland habitats in Hawaii, including managed refuges, have been altered or influenced considerably by a number of factors. Providing areas with habitat components that allow waterbirds to survive and reproduce successfully, requires active management. Management steps necessary for enhancing habitat for Hawaii's endangered waterbirds are outlined below. A number of these steps are already being implemented on protected wetland areas. Table 2 indicates actions that need to be implemented for particular wetland areas.

121. Manage water levels to maximize nesting success, brood survival, food availability, and recruitment.

Hydrology is the key element to maintaining productive wetland habitat. An adequate water source of satisfactory quality must be obtained and sustained. Water levels must be dynamic to enhance productivity of wetland food sources and to provide suitable vegetative cover.

122. Manage vegetation to maximize nesting success, brood survival, food availability, and recruitment.

The composition and distribution of vegetation in a wetland ecosystem determines the habitat's value. Unfortunately, most of Hawaii's wetlands have been extensively altered such that active vegetation management is required in order to provide useful habitat.

1221. Encourage desirable species.

Certain types of vegetation provide the optimal feeding and nesting conditions for waterbirds. Habitat management efforts should be aimed at developing optimum distribution and density of these species.

1222. Control noxious plants.

Undesirable plants, mainly introduced species, make wetlands less useful or unusable for waterbirds. These plants should be eliminated or controlled. In many cases, water level management can be used to control noxious species. Some indigenous species might pose a problem as they overgrow wetlands and result in monocultures. Control methods that do not introduce environmental contaminants and that can be sustained over the long term should be employed.

123. Control predators.

Predation is a major cause of waterbird mortality. Introduced mammals such as mongooses, cats, dogs, and rats are the primary predators, but some depredation by avian species has been documented. Adult waterbirds are occasionally taken, but most depredation is of eggs and young.

1231. Prevent predator access.

One means of controlling predators is by preventing their access to nesting habitat. This can be accomplished by the use of barrier moats or fencing.

1232. Eliminate or reduce populations of predators.

Some predators will inevitably find access to waterbird areas, and attempts must be made to eliminate or control these animals.

12321. Control mongoose.

Mongooses are the most serious predation threat to Hawaii's waterbirds. Trapping of mongooses has been proven to increase waterbird reproduction and should be actively pursued wherever possible. Other methods such as the use of toxicants should be investigated.

12322. Control feral cats.

Feral cats are predators of waterbirds and should be controlled where they are a significant problem.

12323. Control feral dogs.

Feral dogs are predators of waterbirds and should be controlled where they are a significant problem.

12324. Control rats.

Rats have been known to take eggs in isolated instances. Rat predation needs to be identified, assessed, and control measures taken as necessary.

12325. Control cattle egrets.

Avian predation and competition for food resources by cattle egrets is poorly understood in Hawaii. Modified habitats and exposed nesting areas make young waterbirds more vulnerable to avian predation. These areas should be identified and improved. Control of cattle egrets in rookeries near, or in, refuges has proven effective and should be continued.

1233. Prevent introduction of new alien predators.

Alien predators are causing severe problems for native waterbirds. Introductions of new predators must be prevented. Special attention is needed to prevent the establishment of mongooses on Kauai, Lanai, and Niihau (where they apparently do not yet occur).

124. Minimize human disturbance to waterbirds and their habitats.

Disturbance or loss of adult and young waterbirds can occasionally be attributed to people. Although such losses are usually restricted to isolated incidents, measures need to be taken to minimize this threat.

1241. Prevent intentional or accidental shooting of waterbirds.

Shooting of waterbirds is reported occasionally and may be only a rare problem. Education and law enforcement should be improved to reduce this problem.

1242. Control human access to sensitive habitats.

Certain habitats and birds are more sensitive to human disturbance. Control of human access to certain habitat areas is needed.

1243. Resolve conflicts resulting from depredation of aquaculture or agriculture developments by waterbirds.

Valuable waterbird habitat often provides multiple uses such as agriculture and aquaculture. There are actual and perceived depredation problems attributed to endangered waterbirds. Wildlife agencies need to respond to these problems to determine the actual extent of problems associated with waterbirds to minimize potential conflicts. Problems which are not associated with waterbirds can be explained and solutions to real problems can be sought before birds or nests are harmed. Open communication between agricultural and waterbird managers is necessary to limit this problem.

1244. Minimize influence of urban encroachment.

Urban encroachment is a significant threat to protected wetland areas in Hawaii. Small wetland preserves, under 50 hectares (125 acres) are particularly susceptible to human intrusion. Issues such as predator control, water quality, and harassment are complicated in an urban setting. This problem has become a recent concern because of the shift in land use from agriculture to housing developments. Refuges that were once surrounded by cane fields are now surrounded by housing tracts or resort developments. The protection of buffer lands around protected wetlands through cooperative agreements or other long-term measures is critical to the function of these habitats. Natural resource agencies and organizations should take a more active part in preliminary regional planning efforts. Buffer lands can provide corridors between wetland refuges within a large complex.

125. Monitor all populations of endangered waterbirds.

Monitoring populations of waterbirds is an important task which helps to assess the success of the recovery program.

1251. Develop adequate census techniques for Hawaii's endangered waterbirds.

Existing census techniques for Hawaii's endangered waterbirds, especially moorhen and koloa, are inadequate. Because of their behavior and the nature of their preferred habitats, these birds are difficult to accurately survey. Techniques need to be developed to provide comparable census results.

1252. Continue standardized semi-annual statewide surveys for all waterbirds.

Semiannual statewide surveys have provided valuable information for gauging the status of endangered waterbirds, particularly coots and stilts. Efforts to further improve surveys should be planned and implemented.

1253. Continue frequent surveys on protected wetlands.

Frequent, intensive surveys on protected wetlands such as State sanctuaries and National Wildlife Refuges, will provide valuable information on short-term population fluctuations.

1254. Monitor reproductive success on key wetlands.

Surveys are needed to determine the reproductive success of endangered waterbirds. Stilt recruitment survey techniques have already been developed. Methodologies for monitoring the reproductive success of the other species should be developed.

126. Monitor and control avian disease epidemics.

Waterbirds and their habitat should be monitored for potential disease problems. When avian diseases are detected, control measures must be rapidly employed.

1261. Monitor waterbird populations to detect disease outbreaks as soon as possible.

Disease monitoring should be a part of wetland area management and incorporated into management plans. Wildlife health professionals should be consulted in order to develop monitoring techniques.

1262. Take immediate action to control severity of disease outbreaks.

When a disease outbreak is identified, Federal and State authorities need to take immediate action to restrict the disease's spread and severity. Disease response actions need to be incorporated into management plans.

127. Minimize contamination of waterbird habitat by toxic substances.

Contamination of waterbird habitats with toxic substances is another potential problem. Because these birds are normally concentrated in small areas, contamination of water or food may affect a relatively large number of birds.

1271. Monitor water quality in key habitats.

Minimizing exposure of waterbirds to contaminants will require consistent monitoring of the habitat. Environmental contaminant monitoring should be incorporated into management plans.

1272. Restrict introduction of contaminants into wetland systems.

To minimize any potential impacts to waterbirds, the introduction of chemicals to wetland areas, either directly or via water supplies should be restricted as much as possible.

The following are additional management tasks needed to reach the downlisting objectives for koloa and moorhen.

13. Remove threat of mallard-koloa hybridization.

Hybridization between koloa and mallards has resulted in a large population of hybrids and a scarcity of genetically pure koloa on the island of Oahu. There is also a threat to koloa on Kauai and Hawaii. Hybridization with mallards or other related waterfowl should be prevented.

131. Implement statewide program to remove mallards and mallard-koloa hybrids.

Measures should be taken to humanely remove domestic and feral mallards, other closely related feral ducks, and mallard-koloa hybrids.

1311. Conduct public information and education program regarding koloa-mallard interbreeding problem and need for the removal program.

The mallard problem will be continual unless the public becomes aware of its significance. The public will also be more willing to cooperate with the program to remove mallards, other closely related feral ducks, and mallard-koloa hybrids from the islands if they understand why it is necessary.

1312. Develop methods for differentiating between koloa and mallard-koloa hybrids.

Methods for identifying mallard-koloa hybrids need to be developed in order to insure that the correct birds are removed from the population. These methods should include genetic markers and field techniques. Genetic markers can be used to confirm field identification of hybrids, thus protecting native koloa. A key outlining those characteristics unique to pure koloa should be developed in order to assist field personnel in proper identification and removal of hybrids.

1313. Remove all mallards and mallard-koloa hybrids from all islands.

Efforts to remove mallards and related waterfowl should be accomplished through approved duck trapping techniques and other humane methods.

132. Ensure that new stocks of mallards and closely related ducks are not brought into the State.

Strict control should be maintained over entry of additional domesticated mallards or closely related ducks into Hawaii. Coordination with the State Department of Agriculture will be necessary to maintain or improve importation bans and reliable controls.

14. Establish a population of moorhen on either Maui/Molokai or Hawaii.

Captive propagation and release to the wild, and translocation have been effective contributions to the recovery of various species. Captive propagation and release or translocation of moorhen should be conducted to help restore these species to their former ranges.

141. Conduct thorough surveys of wetland areas on Maui, Molokai, and Hawaii to confirm that a population does not already exist.

It is possible that a population of moorhen could already exist on the islands of Maui, Molokai, or Hawaii. While this possibility is probably slim, all likely moorhen habitat areas should be thoroughly searched.

142. If a population of moorhen is found on Maui, Molokai, or Hawaii, its wetland habitat should be protected and managed.

Any moorhen population found on the islands of Maui, Molokai, or Hawaii, should be increased through habitat protection and management.

143. If no population of moorhen is found on Maui, Molokai, or Hawaii, sites for reintroduction of this species should be identified.

Wetlands that are currently under protected status (Table 1) should be considered first for sites of moorhen reintroduction. If none of these areas are suitable, the additional primary habitats (listed in task 21) should be considered before consideration is given to other areas.

144. Investigate the pros and cons of captive propagation versus translocation.

The pros and cons of captive propagation versus translocation should be investigated in order to determine which method is likely to be more successful for reestablishing a population.

145. Reintroduce either captive-bred or translocated moorhen to a protected and managed site on Maui, Molokai, or Hawaii.

Depending on the outcome of task 144, either captive propagation or translocation should be used to reestablish a population.

2. Protect and manage additional primary habitats.

In order to provide sufficient habitat to allow for the delisting of Hawaii's endangered waterbirds, additional primary habitats must be protected and managed.

21. Provide long-term protection of additional primary wetland habitat areas that are not currently secured (listed below).

211. Protect Playa Lakes, Niihau.

The Playa Lakes on Niihau are seasonally some of the most important wetlands in the State. Three large lakes dominate the 760 hectare (1,900 acre) wetland complex. Large numbers of coots, stilt, and koloa are regularly observed on these lakes. The long-term protection of these wetlands should be secured through a cooperative effort with the private land owner.

212. Protect Opaekaa Marsh, Kauai.

Adjacent to the Wailua River, Opaekaa Marsh is a 20 hectare (50 acre) wetland that supports moorhen, coot, and koloa. The State already owns portions of the land. Protection of additional private land, and restoration of managed units, could create an important wetland refuge.

213. Protect Mana Wetlands, Kauai.

Approximately 81 hectares (200 acres) of ponds, ditches, reservoirs, and flooded pastures remain from what was once a 810 hectare (2,000 acre) wetland expanse. Presently there is considerable use of this area by all four waterbird taxa. Further habitat restoration and management of the area is necessary to realize its potential for waterbirds. Although a formal cooperative agreement between the State, Kekaha Sugar Company, and Hawaiian Homelands declares the Mana Plain a wildlife sanctuary, a more formal designation of specific waterbird areas should be made. The decline of the sugar industry in Hawaii puts future land use in this area in question.

214. Protect Lumahai Valley, Kauai.

The mouth of Lumahai Valley consists of about 50 hectares (125 acres) of former rice and taro fields, now reverted to wet meadow. This area provides feeding and resting habitat for coots and moorhens.

215. Protect Amorient Prawn Farms, Oahu.

Until early 1994, this was one of the largest aquaculture developments in the State. Good feeding and marginal nesting habitats are available here for all four endangered waterbird species. We are seeking fee title to these ponds to ensure long-term protection.

216. Protect Laie Wetlands, Oahu.

This 80-hectare (200-acre) wetland complex is comprised of three natural ponds and several aquaculture ponds. All are linked hydrologically and all four endangered waterbirds use the site. This area is owned by the Church of Jesus Christ of Latter-day Saints and long-term protection is planned for the site. If restored and managed, the Laie Wetlands would be an important addition to the available wetland habitat in the Kahuku area.

217. Protect Ukoa Marsh, Oahu.

This is a 120-hectare (300-acre) freshwater marsh near Haleiwa on the north shore. Much of this privately owned marsh has been overgrown by alien plants, but it still provides valuable waterbird habitat. The U.S. Fish and Wildlife Service, State, and Ducks Unlimited have begun cooperative agreement negotiations with the private land owner.

218. Protect Punahoolapa Marsh, Oahu.

This former pond and large marsh of over 40 hectares (100 acres) has been highly altered due to the development of a golf course resort. The golf course surrounds the site, and a second planned resort will impact its coastal buffer. All four endangered waterbird species are known to use this area. It should be incorporated into the refuge system as part of the James Campbell National Wildlife Refuge.

219. Protect Waialua lotus fields, Oahu.

Relatively few taro and lotus fields remain in what was once a large wetland agriculture development on the north shore of Oahu. The lotus fields in Waialua support the State's highest known concentration of moorhen, who use the area to nest and feed. Stilts, numerous shorebirds, and night-herons also feed in the wetland. Long-term protection of this subsistence formed resource could be reached through cooperative agreements between landowners and natural resource agencies.

2110. Protect Waihee Marsh, Oahu.

This 10-hectare (25-acre) marsh is located along the windward coast of Oahu near the town of Waiahole. It supports limited numbers of waterbirds. Protection and enhancement could improve its value to endangered waterbirds.

2111. Reestablish and protect Waipio Peninsula Ponds, Oahu.

Waipio Peninsula's wetlands were diverse, ranging from tidal mudflats to wastewater ponds for sugar effluent. In 1994, the Oahu Sugar Company went out of business and the Waipahu Mill was closed. The ponds that captured sugar effluent are still present but are now dry. These ponds, in concert with natural wetlands, once supported numerous waterbirds, both native and migratory. The U.S. Navy is planning the long-term use of the land on Waipio Peninsula, which is under a sphere of protection from development. Agriculture seems the most viable land use. Reestablishing the ponds and managing them for native waterbirds should be negotiated with the U.S. Navy. Water rights should be secured for these ponds.

2112. Protect Paialoa, Molokai.

This is a privately owned freshwater marsh, about 2 hectares (5 acres) in size, used by coots and stilts. A cooperative agreement should be arranged with the land owner to prevent habitat alteration.

2113. Protect Ooia-Kaluaapuhi Ponds, Molokai.

Located west of Kaunakakai, these ponds currently flood during wet winters, and the ephemeral wetlands support stilts and other shorebirds. Monitoring of bird populations and mechanisms for protection should be sought.

2114. Protect Opaeula Pond, Hawaii.

This 3-hectare (7.5-acre) privately-owned pond is located in the North Kona District. Vegetation has choked a good portion of this important wetland and feral goats have ready access to waterbird foraging and nesting sites.

2115. Protect montane stock ponds, Hawaii.

Several ponds located on the slopes of Mauna Kea and in the Kohala Mountains are owned by State, Federal, and private landowners. These ponds support most of the reproducing population of koloa on the Big Island. Protection and enhancement of these ponds should be accomplished through cooperative efforts between agencies and private ranchers leasing the lands. Ducks Unlimited has been actively working with Natural Resources Conservation Service in enhancing these opportunities.

2116. Protect Waiakea-Loko Waka Ponds, Hawaii.

The Loko Waka Ponds are located near Hilo and the private portions are managed for fish culture purposes. They provide nesting and feeding habitat for coots. The use of pesticides should be closely coordinated with the State Division of Aquatic Resources to prevent habitat damage. Agreements with the land owner should be sought to enhance habitat for waterbirds. The public areas of these ponds near Hilo are managed for recreational fishing purposes. They offer marginal habitat value for coots. Vegetation and water control management may increase the habitat value of Loko Waka Pond (State of Hawaii). Technical assistance to private land managers could allow for enhancement of habitat values to waterbirds. Waiakea Pond (County of Hawaii) harbors a large number of feral mallards that should be removed.

22. Develop management plans for additional primary wetland habitat areas (listed above).

The acquisition or protection of waterbird habitat areas must be followed with an active planning process to identify management and habitat enhancement goals. The development of plans will help to obtain funding for restoration, provide for annual operations and maintenance budgets, and project management continuity when staff changes are made. Plans can be flexible and updated frequently as new methods are developed and incorporated into management schemes. See Table 2 for site-specific management recommendations as outlined by this plan.

23. Implement management plans for additional primary wetland habitat areas (listed in task 21).

Refer to tasks 121 through 127.

24. Coordinate management within watersheds and coastal wetland complexes.

Recognizing that Hawaiian waterbirds are highly mobile and disperse seasonally, wetland management and restoration should be undertaken in a coordinated effort. This may require coordination of several agencies to ensure proper habitat regimes. Management planning for new refuges should be coordinated with those in existence.

25. Conduct biannual, interagency, management workshops to develop statewide coordination of waterbird/wetlands management.

Managers charged with the care of refuges and sanctuaries have developed numerous methods of habitat management and micromanagement. These techniques vary in the islands (and from island to island, and manager to manager). Interagency management workshops should be regularly conducted in Hawaii. These meetings should provide a professional forum for presentation of management methodology practiced in Hawaii as well as develop new methods, find solutions to shared management problems, and provide for a statewide approach to wetlands stewardship.

The following are additional management tasks needed to reach the delisting objectives for koloa and moorhen.

26. Establish a population of moorhen either on Maui/Molokai or Hawaii.

A population of moorhen should be established on either Maui/Molokai or Hawaii, whichever island does not yet have a moorhen population following accomplishment of task 14.

27. Establish a population of koloa on Maui/Molokai.

The reintroduction of koloa to the species' former range can only be accomplished after hybrids and pure mallards are removed (task 13). The techniques for breeding koloa in captivity have been developed, however translocation might also prove to be a successful method of reintroduction.

271. Conduct thorough surveys of wetland areas on Maui and Molokai to confirm that a population does not already exist.

It is possible that a population of koloa could already exist on the islands of Maui or Molokai. While this possibility is probably slim, all likely koloa habitat areas should be thoroughly searched.

272. If a population of koloa is found on Maui or Molokai, its habitat should be protected and managed.

Any koloa population found on the islands of Maui or Molokai should be increased through habitat protection and management.

273. If no population of koloa is found on Maui or Molokai, sites for reintroduction of this species should be identified.

Wetlands that are currently under protected status (Table 1) should be considered first for sites of koloa reintroduction. If none of these areas are suitable, the additional primary habitats (listed in task 21) should be considered before consideration is given to other areas.

274. Investigate the pros and cons of captive propagation versus translocation.

The pros and cons of captive propagation versus translocation should be investigated in order to determine which method is likely to be more successful for reestablishing a population. Techniques for captive propagation of koloa have been developed; however, translocation may prove to be a valuable method of reintroduction.

275. Reintroduce either captive-bred or translocated koloa to a protected and managed site on Maui, Molokai, or Hawaii.

Depending on the outcome of task 274, either captive propagation or translocation should be used to reestablish a population.

3. Conduct research to better define limiting factors, determine recovery objectives, and improve management techniques.

Proper management requires application of information obtained from sound research. Many of the successful waterbird management techniques currently in use were developed in response to research findings. Additional research is needed to better understand limiting factors, determine recovery objectives, and improve management techniques.

31. Increase understanding of limiting factors.

A better understanding of the factors that limit the recovery of Hawaii's waterbirds will allow more effective management techniques to be developed.

311. Conduct research on improved predator control methods.

The effectiveness of current predator control efforts needs to be evaluated. Improved predator control methods should be developed. Approvals for specific toxicants require a significant amount of time, which should be factored into management research plans.

312. Conduct research on improved alien plant control methods.

Improved methods for controlling alien plants in order to make habitat areas more suitable for waterbird use should be developed.

313. Conduct research on water sources that supply water to important wetlands.

Hydrological research should be conducted in order to determine the source of and any potential threats to the water supplies of important wetlands.

314. Determine the effects of avian predators on populations of the four endangered waterbirds.

The effects of black-crowned night-herons, cattle egrets, owls, and other birds need to be investigated.

32. Conduct research in order to determine scientifically defensible recovery objectives.

A sound base of knowledge must be obtained before statistically valid techniques can be used to arrive at scientifically defensible recovery objectives. A number of types of information are required in order to determine valid recovery criteria.

321. Conduct research on current population size, effective population size, and recent trends.

Determine population numbers and trends of all four endangered waterbird species.

322. Conduct research on carrying capacity of available habitat.

Determine carrying capacities of available habitat for all four endangered waterbird species.

323. Conduct research on the sex and age structure of populations.

Determine sex and age structures of important populations of all four endangered waterbird species.

324. Conduct research on reproductive parameters.

Determine reproductive parameters of all four endangered waterbird species. This research should focus on the following areas: age at first breeding, nest site and mate fidelity, length of nesting season, clutch size, hatching and fledging rates, nesting attempts per pair, and total nesting attempts.

325. Conduct research on mortality rates.

Determine mortality rates of important populations of all four endangered waterbird species.

326. Conduct research on inbreeding depression.

Determine the degree of inbreeding depression in important populations of all four endangered waterbird species.

4. Conduct public education and information program to increase public awareness and support for waterbird recovery.

The waterbird recovery program cannot be fully successful without a well informed and supportive public. Efforts need to be made to inform the public and provide information on the various programs outlined in this plan.

41. Prepare and distribute television and radio spots, written information, slide programs, videos, films, posters, and displays.

Educational materials should be prepared which will reach a wide cross-section of the public.

42. Coordinate with the State Department of Education and private schools to incorporate wetland and waterbird information into curricula.

Efforts to teach wetland principles and avian biology should be made within the public and private school systems. Wetland refuges provide excellent opportunities for field trips.

43. Develop and maintain interpretive public displays of endangered waterbirds and wetlands.

Interpretive displays should be developed and maintained at wetland habitat areas and at various community locations.

5. Validate recovery objectives.

The scientific validity of the stated recovery objectives must be evaluated.

51. Conduct statistical analyses in order to determine minimum viable populations.

Results from research recommended in task 32 should be statistically analyzed in order to determine minimum viable populations.

52. Revise recovery objectives.

Recovery objectives should be revised if analysis suggests that the current objectives are inadequate.

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PART III. IMPLEMENTATION SCHEDULE

The Implementation Schedule that follows outlines actions and estimated costs for the Hawaiian Waterbird recovery program, as set forth in this recovery plan. It is a guide for meeting the objectives discussed in Part II of this plan. This schedule indicates task priority, task numbers, task descriptions, duration of tasks, the agencies responsible for committing funds, and lastly, estimated costs. The agencies responsible for committing funds are not, necessarily, the entities that will actually carry out the tasks. When more than one agency is listed as the responsible party, an asterisk is used to identify the lead entity.

The actions identified in the Implementation Schedule, when accomplished, should protect habitat for these species, stabilize their existing populations, and increase their population sizes and numbers. Monetary needs for all parties involved are identified to reach this point.

Priorities in Column 1 of the following Implementation Schedule are assigned as follows:

Priority 1 -	An action that must be taken to prevent extinction or to prevent the species from declining irreversibly.
Priority 2 -	An action that must be taken to prevent a significant decline in species population, habitat quality, or some other significant negative impact short of extinction.
Priority 3 -	All other actions necessary to provide for full recovery of the species.

Key to acronyms and symbols used in the Implementation Schedule:

WS - U.S. Department of Agriculture, Wildlife Services (formerly Animal Damage Control)

ES - U.S. Fish and Wildlife Service, Ecological Services, Honolulu, Hawaii

FWS-LE - U.S. Fish and Wildlife Service, Law Enforcement

FWS-R - U.S. Fish and Wildlife Service, Refuges

DOCARE - Division of Conservation and Resources Enforcement

DOFAW - Hawaii State Division of Forestry and Wildlife

DU - Ducks Unlimited

HDOA - Hawaii State Department of Agriculture

BRD - U.S. Geological Survey, Biological Resources Division (formerly National Biological Survey)

USDA - U.S. Department of Agriculture

USN - U.S. Navy

C - Continuous Task

O - Ongoing Task

TBD - To be determined

* - Indicates the lead agency. When the asterisk is absent, the lead is shared equally among agencies.

RECOVERY PLAN IMPLEMENTATION SCHEDULE FOR THE HAWAIIAN WATERBIRDS

Priority Number	Task Number	Task Description	Task Duration (Years)	Responsible Party	Total Cost (first 5 years)	Cost Estimates ($1,000's)					
						FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	Comments
Tasks 11-145 are needed to reach downlisting objectives											
1	11	Develop management plans for protected wetland habitats.	8	FWS-R	100.0	20	20	20	20	20	
				DOFAW	100.0	20	20	20	20	20	
				USN	20.0	20					
1	121	Manage water levels.	C	FWS-R	600.0	120	120	120	120	120	
				DOFAW	800.0	160	160	160	160	160	
1	1221	Encourage desirable plant species.	C	FWS-R	600.0	120	120	120	120	120	
				DOFAW	800.0	160	160	160	160	160	
1	1222	Control undesirable plant species.	C	FWS-R	600.0	120	120	120	120	120	
				DOFAW	800.0	160	160	160	160	160	
1	1231	Prevent predator access.	C	FWS-R	300.0	60	60	60	60	60	
				DOFAW	400.0	80	80	80	80	80	
1	12321	Control mongoose.	C	FWS-R	150.0	30	30	30	30	30	
				DOFAW	200.0	40	40	40	40	40	
1	12322	Control feral cats.	C	FWS-R	150.0	30	30	30	30	30	
				DOFAW	200.0	40	40	40	40	40	
1	12323	Control feral dogs.	C	FWS-R	150.0	30	30	30	30	30	
				DOFAW	200.0	40	40	40	40	40	

RECOVERY PLAN IMPLEMENTATION SCHEDULE FOR THE HAWAIIAN WATERBIRDS

Priority Number	Task Number	Task Description	Task Duration (Years)	Responsible Party	Total Cost (first 5 years)	Cost Estimates ($1,000's)					
						FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	Comments
1	12324	Control rats.	C	FWS-R	150.0	30	30	30	30	30	
				DOFAW	200.0	40	40	40	40	40	
1	12325	Control cattle egrets.	C	FWS-R	150.0	30	30	30	30	30	
				DOFAW	200.0	40	40	40	40	40	
1	1233	Prevent introduction of new alien predators.	C	ES	25.0	5	5	5	5	5	
				DOFAW	25.0	5	5	5	5	5	
				HDOA	25.0	5	5	5	5	5	
1	1241	Prevent shooting of waterbirds.	O	FWS-R	25.0	5	5	5	5	5	
				FWS-LE	25.0	5	5	5	5	5	
				*DOCARE	50.0	10	10	10	10	10	
1	1242	Control human access to sensitive habitat.	C	FWS-R	25.0	5	5	5	5	5	
				DOFAW	25.0	5	5	5	5	5	
1	1243	Resolve conflicts resulting from waterbird depredation of aquaculture and agriculture developments.	C	ES	10.0	2	2	2	2	2	
				FWS-R	15.0	3	3	3	3	3	
				DOFAW	25.0	5	5	5	5	5	
1	1244	Minimize influence of urban encroachment.	C	ES	25.0	5	5	5	5	5	
				FWS-R	25.0	5	5	5	5	5	
				DOFAW	25.0	5	5	5	5	5	

RECOVERY PLAN IMPLEMENTATION SCHEDULE FOR THE HAWAIIAN WATERBIRDS

Priority Number	Task Number	Task Description	Task Duration (Years)	Responsible Party	Total Cost (first 5 years)	Cost Estimates ($1,000's)					
						FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	Comments
1	1251	Develop adequate census techniques for Hawaii's endangered waterbirds.	2	BRD	40.0	20	20				
1	1252	Continue semi-annual, statewide waterbird surveys for all four species.	O	*DOFAW	5.0	1	1	1	1	1	
				FWS-R	2.5	.5	.5	.5	.5	.5	
				ES	2.5	.5	.5	.5	.5	.5	
1	1253	Continue frequent surveys on protected wetlands.	O	DOFAW	25.0	5	5	5	5	5	
				FWS-R	25.0	5	5	5	5	5	
1	1254	Monitor reproductive success on primary wetlands.	C	FWS-R	25.0	5	5	5	5	5	
				DOFAW	25.0	5	5	5	5	5	
1	1261	Monitor waterbird populations to detect disease outbreaks as soon as possible.	C	FWS-R	10.0	2	2	2	2	2	
				DOFAW	10.0	2	2	2	2	2	
				BRD	3.0	1	1	1			
1	1262	Take immediate action to restrict spread of disease outbreaks.	TBD	FWS-R	TBD						
				DOFAW	TBD						
				*BRD	TBD						
1	1271	Monitor water quality.	O	FWS-R	10.0	2	2	2	2	2	
				DOFAW	10.0	2	2	2	2	2	
				ES	4.0	2	2				

RECOVERY PLAN IMPLEMENTATION SCHEDULE FOR THE HAWAIIAN WATERBIRDS

Priority Number	Task Number	Task Description	Task Duration (Years)	Responsible Party	Total Cost (first 5 years)	Cost Estimates ($1,000's)					
						FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	Comments
1	1272	Restrict introduction of contaminants to wetland habitats	O	FWS-R	5.0	1	1	1	1	1	
				DOFAW	10.0	2	2	2	2	2	
				ES	5.0	1	1	1	1	1	
1	1311	Conduct public education program regarding mallard-koloa interbreeding problem	2	DOFAW	20.0			10	10		
				ES	20.0			10	10		
1	1312	Develop methods for differentiating between koloa and mallard-koloa hybrids	2	*BRD	80.0	40	40				
				ES	80.0	40	40				
1	1313	Remove all feral mallards and mallard-koloa hybrids from all islands	3	DOFAW	80.0				40	40	
				FWS-R	80.0				40	40	
				WS	80.0				40	40	
1	132	Ensure that new stocks of mallards and related ducks are not brought into the state	O	*HDOA	10.0	2	2	2	2	2	
				FWS-LE	10.0	2	2	2	2	2	
1	141	Conduct surveys for moorhen on Maui, Molokai, and Hawaii	1	DOFAW	4.0		4				
				FWS-R	2.0		2				
				ES	2.0		2				
1	142	If moorhen population is found, protect habitat.	2	FWS-R	TBD			TBD			
				DOFAW	TBD			TBD			

RECOVERY PLAN IMPLEMENTATION SCHEDULE FOR THE HAWAIIAN WATERBIRDS

Priority Number	Task Number	Task Description	Task Duration (Years)	Responsible Party	Total Cost (first 5 years)	Cost Estimates ($1,000's)					
						FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	Comments
1	143	If no moorhen population is found, identify release site.	1	DOFAW	0.0			TBD			
				ES	0.0			TBD			
				FWS-R	0.0			TBD			
1	144	Investigate pros and cons of captive propagation versus translocation.	1	DOFAW	40.0			40			
				BRD	40.0			40			
1	145	Reintroduce moorhen to a protected, managed site on Maui, Molokai, or Hawaii.	8	DOFAW	160.0				80	80	
				ES	160.0				80	80	
				BRD	160.0				80	80	
NEED 1 (Manage protected wetland habitats) Tasks 211-52 are needed to reach delisting objectives					8,465.0	1,601	1,589	1,579	1,858	1,838	
2	211	Protect Playa Lakes, Niihau.	C	DOFAW	TBD		TBD				
				ES	TBD		TBD				
2	212	Protect Opaekaa Marsh, Kauai.	C	DOFAW	TBD		TBD				
2	213	Protect Mana Wetlands, Kauai.	C	DOFAW	TBD		TBD				
2	214	Protect Lumahai Wetlands, Kauai.	C	DOFAW	TBD		TBD				
				ES	TBD		TBD				
2	215	Protect Amorient prawn farms, Oahu.	C	FWS-R	TBD		TBD				

RECOVERY PLAN IMPLEMENTATION SCHEDULE FOR THE HAWAIIAN WATERBIRDS

Priority Number	Task Number	Task Description	Task Duration (Years)	Responsible Party	Total Cost (first 5 years)	Cost Estimates ($1,000's)					
						FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	Comments
2	216	Protect Laie Wetlands, Oahu.	C	DOFAW	TBD		TBD				
				ES	TBD		TBD				
2	217	Protect Ukoa Marsh, Oahu.	C	ES	TBD		TBD				
				DOFAW	TBD		TBD				
				DU	TBD		TBD				
2	218	Protect Punahoolapa Marsh, Oahu.	C	FWS-R	TBD		TBD				
2	219	Protect Waialua lotus fields, Oahu.	C	DOFAW	TBD		TBD				
				ES	TBD		TBD				
				DU	TBD		TBD				
2	2110	Protect Waihee Marsh, Oahu.	C	DOFAW	TBD		TBD				
				ES	TBD		TBD				
2	2111	Protect Waipio Peninsula Ponds, Oahu.	C	FWS-R	TBD		TBD				
				USN	TBD		TBD				
2	2112	Protect Paialoa, Molokai.	C	ES	TBD		TBD				
				DOFA	TBD		TBD				
				DU	TBD		TBD				

RECOVERY PLAN IMPLEMENTATION SCHEDULE FOR THE HAWAIIAN WATERBIRDS

Priority Number	Task Number	Task Description	Task Duration (Years)	Responsible Party	Total Cost (first 5 years)	Cost Estimates ($1,000's)					
						FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	Comments
2	2113	Protect Ooia Playa-fish ponds, Molokai.	C	ES	TBD		TBD				
				DOFAW	TBD		TBD				
				DU	TBD		TBD				
2	2114	Protect Opaeula Pond, Hawaii.	C	ES	TBD		TBD				
				DOFAW	TBD		TBD				
2	2115	Protect Montane Stock Ponds, Hawaii.	C	DU	TBD		TBD				
				DOFAW	TBD		TBD				
				ES	TBD		TBD				
2	2116	Protect Waiakea-Lokowaka Ponds, Hawaii.	C	DU	TBD		TBD				
				ES	TBD		TBD				
				DOFAW	TBD		TBD				
2	22	Develop management plans for additional primary wetland habitat areas.	7	FWS-R	60.0			20	20	20	
				DOFAW	60.0			20	20	20	
				DU	60.0			20	20	20	
2	23	Implement management plans for additional primary wetland habitat areas (refer to tasks 121-127).	C	FWS-R	400.0				100	300	
				DOFAW	400.0				100	300	

RECOVERY PLAN IMPLEMENTATION SCHEDULE FOR THE HAWAIIAN WATERBIRDS

Priority Number	Task Number	Task Description	Task Duration (Years)	Responsible Party	Total Cost (first 5 years)	Cost Estimates ($1,000's)					
						FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	Comments
2	24	Establish population of moorhen on either Maui/Molokai or Hawaii.	8	DOFAW	0.0						
				ES	0.0						
				BRD	0.0						
2	251	Conduct surveys for koloa on Maui and Molokai.	1	DOFAW	4.0		4				
				FWS-R	2.0		2				
				ES	2.0		2				
2	252	If koloa population is found, protect habitat.	2	FWS-R	TBD			TBD	TBD		
				DOFAW	TBD			TBD	TBD		
2	253	If no koloa population is found, identify release site.	1	DOFAW	0.0			TBD			
				ES	0.0			TBD			
				FWS-R	0.0			TBD			
2	254	Investigate pros and cons of captive propagation versus translocation.	1	DOFAW	10.0			10			
				BRD	40.0			40			
2	255	Reintroduce koloa to a protected, managed site on Maui or Molokai.		*DOFAW	160.0				80	80	
				ES	160.0				80	80	
				BRD	160.0				80	80	
NEED 2 (Protect and manage other primary habitats)					1,518.0	0	8	110	500	900	

RECOVERY PLAN IMPLEMENTATION SCHEDULE FOR THE HAWAIIAN WATERBIRDS

Priority Number	Task Number	Task Description	Task Duration (Years)	Responsible Party	Total Cost (first 5 years)	Cost Estimates ($1,000's)					
						FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	Comments
2	311	Conduct research on improved predator control methods.	3	FWS-R	120.0	40	40	40			
				DOFAW	120.0	40	40	40			
				*BRD	120.0	40	40	40			
				WS	120.0	40	40	40			
2	312	Conduct research on improved alien plant control methods.	3	FWS-R	120.0	40	40	40			
				DOFAW	120.0	40	40	40			
				*BRD	120.0	40	40	40			
2	313	Conduct research on water sources of important wetlands.	5	FWS-R	200.0	40	40	40	40	40	
				DOFAW	200.0	40	40	40	40	40	
2	314	Determine effects of avian predators.	5	FWS-R	100.0	20	20	20	20	20	
				DOFAW	100.0	20	20	20	20	20	
				BRD	100.0	20	20	20	20	20	
2	321	Conduct research on population size, effective population size, and recent population trends.	5	*BRD	100.0	20	20	20	20	20	
				FWS-R	100.0	20	20	20	20	20	
				DOFAW	100.0	20	20	20	20	20	
				ES	100.0	20	20	20	20	20	

RECOVERY PLAN IMPLEMENTATION SCHEDULE FOR THE HAWAIIAN WATERBIRDS

Priority Number	Task Number	Task Description	Task Duration (Years)	Responsible Party	Total Cost (first 5 years)	Cost Estimates ($1,000's)					
						FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	Comments
2	322	Conduct research on carrying capacity of available habitat.	5	*BRD	100.0	20	20	20	20	20	
				ES	100.0	20	20	20	20	20	
				DOFAW	100.0	20	20	20	20	20	
				FWS-R	100.0	20	20	20	20	20	
2	323	Conduct research on the sex and age structure of populations.	5	BRD	100.0	20	20	20	20	20	
				ES	100.0	20	20	20	20	20	
				DOFAW	100.0	20	20	20	20	20	
				FWS-R	100.0	20	20	20	20	20	
2	324	Conduct research on reproductive parameters.	5	BRD	100.0	20	20	20	20	20	
				ES	100.0	20	20	20	20	20	
				DOFAW	100.0	20	20	20	20	20	
				FWS-R	100.0	20	20	20	20	20	
2	325	Conduct research on mortality rates.	5	BRD	100.0	20	20	20	20	20	
				ES	100.0	20	20	20	20	20	
				DOFAW	100.0	20	20	20	20	20	
				FWS-R	100.0	20	20	20	20	20	

RECOVERY PLAN IMPLEMENTATION SCHEDULE FOR THE HAWAIIAN WATERBIRDS

Priority Number	Task Number	Task Description	Task Duration (Years)	Responsible Party	Total Cost (first 5 years)	Cost Estimates ($1,000's)					
						FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	Comments
2	326	Conduct research on inbreeding depression.	5	*BRD	100.0	20	20	20	20	20	
				ES	100.0	20	20	20	20	20	
				DOFAW	100.0	20	20	20	20	20	
				FWS-R	100.0	20	20	20	20	20	
NEED 3 (Conduct research)					3,940.0	900	900	900	620	620	
2	41	Prepare and distribute educational material.	C	ES	46.0	20	20	2	2	2	
				DOFAW	46.0	20	20	2	2	2	
				FWS-R	6.0			2	2	2	
2	42	Incorporate waterbird information into school curricula.	C	DOFAW	40.0	20	20				
				ES	40.0	20	20				
				HDOE	40.0	20	20				
2	43	Develop and maintain public wetland and waterbird displays.	C	DOFAW	40.0	20	20				
				ES	40.0	20	20				
				FWS-R	40.0	20	20				
NEED 4 (Conduct public education & information program)					338.0	160	160	6	6	6	
2	51	Conduct statistical analyses in order to determine minimum viable populations.	2	*BRD	0.0						
				ES	0.0						
2	52	Revise recovery objectives.	1	ES	0.0						

RECOVERY PLAN IMPLEMENTATION SCHEDULE FOR THE HAWAIIAN WATERBIRDS

Priority Number	Task Number	Task Description	Task Duration (Years)	Responsible Party	Total Cost (first 5 years)	Cost Estimates ($1,000's)					
						FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	Comments
NEED 5 (Validate recovery objectives)					0.0	0	0	0	0	0	
TOTAL COST OF THE FIRST 5 YEARS OF RECOVERY [1]					14,261.0	2,661	2,657	2,595	2,984	3,364	

[1] Some Costs are yet to be determined. The estimated total cost for 13 years of recovery activity is $41,313,000 as shown in the Executive Summary.

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APPENDIX B. Core Wetland Habitat Location Maps

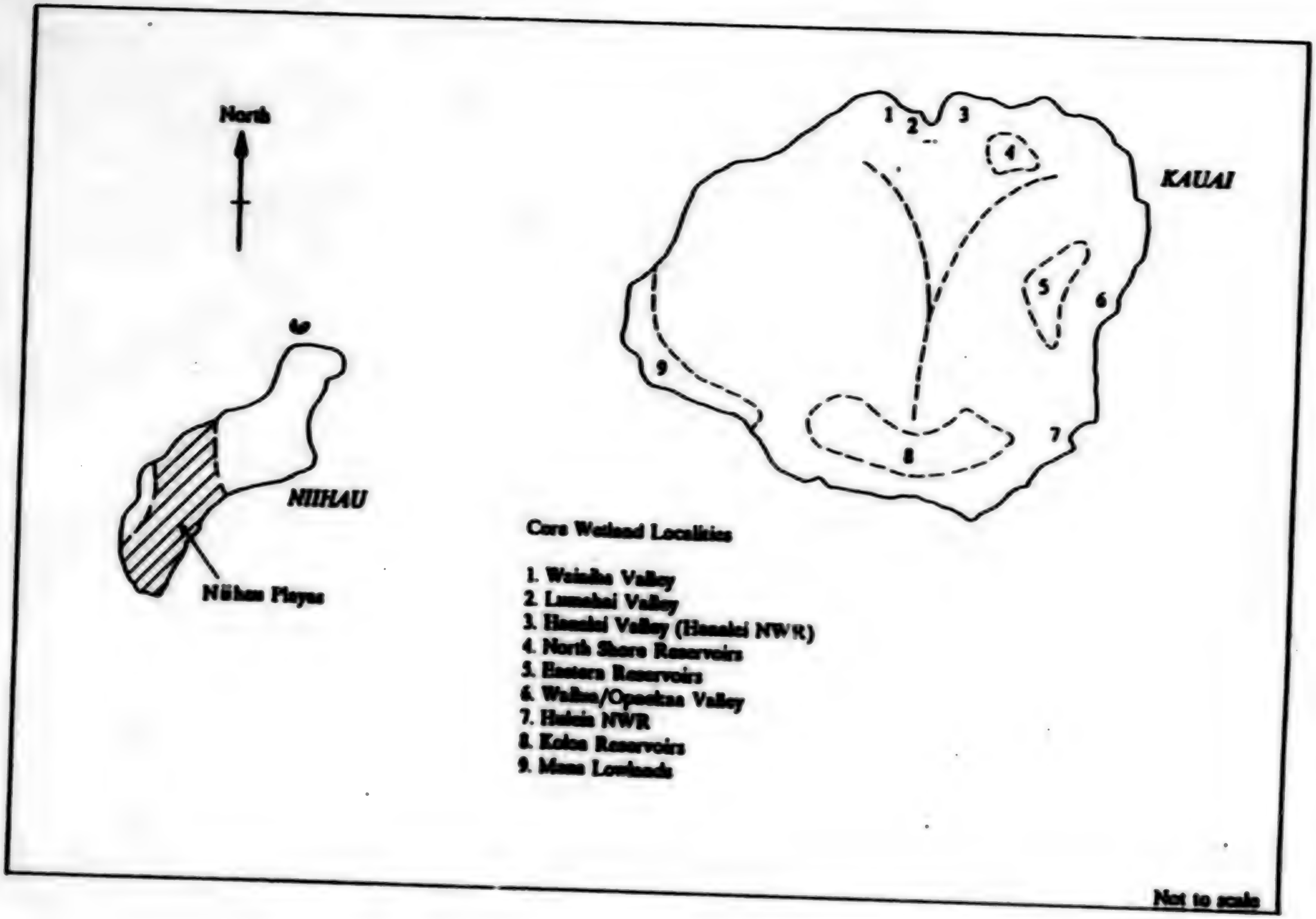


Figure 6. Core wetland localities on the islands of Niihau and Kauai.

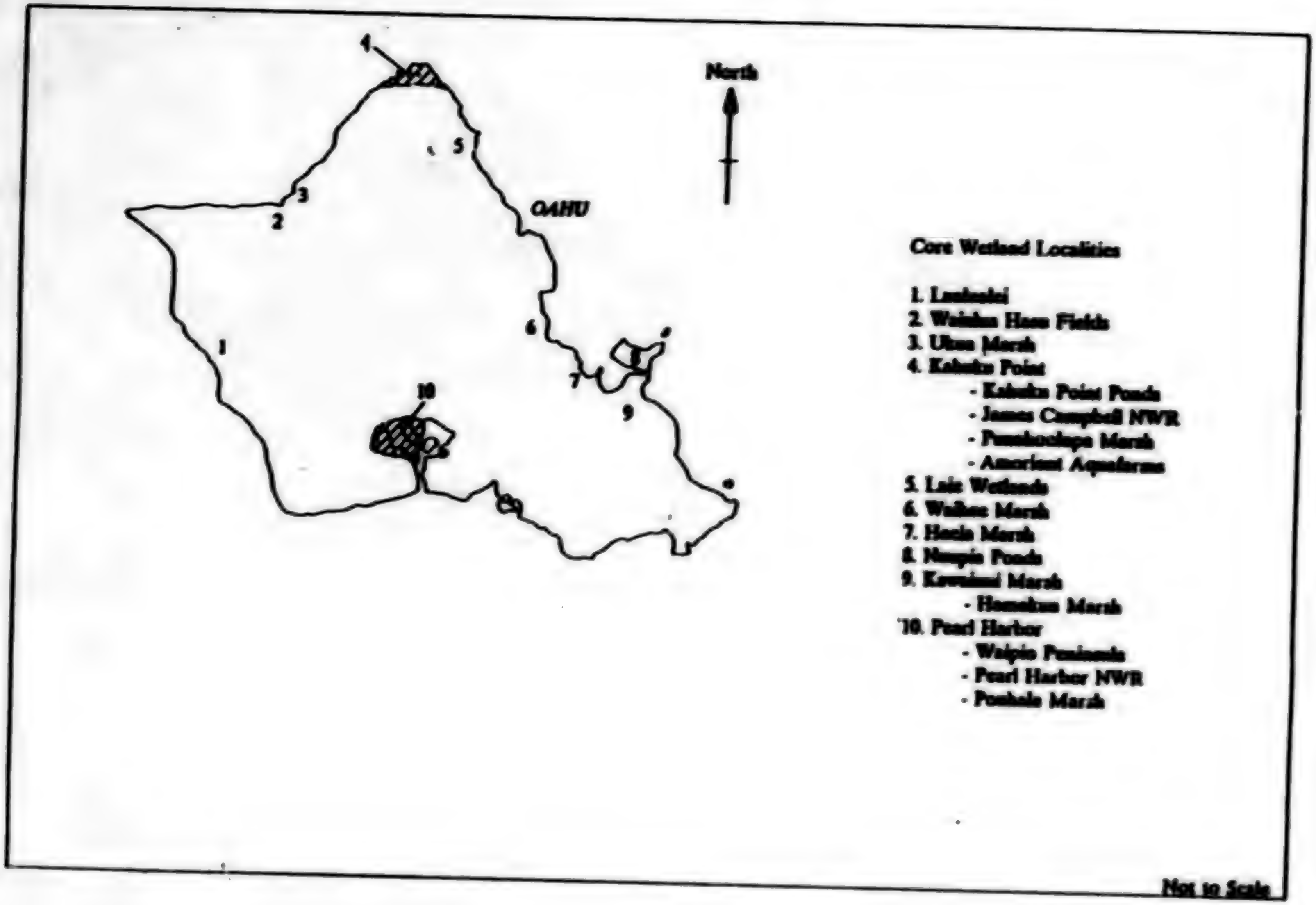


Figure 7. Core wetland localities on the island of Oahu.

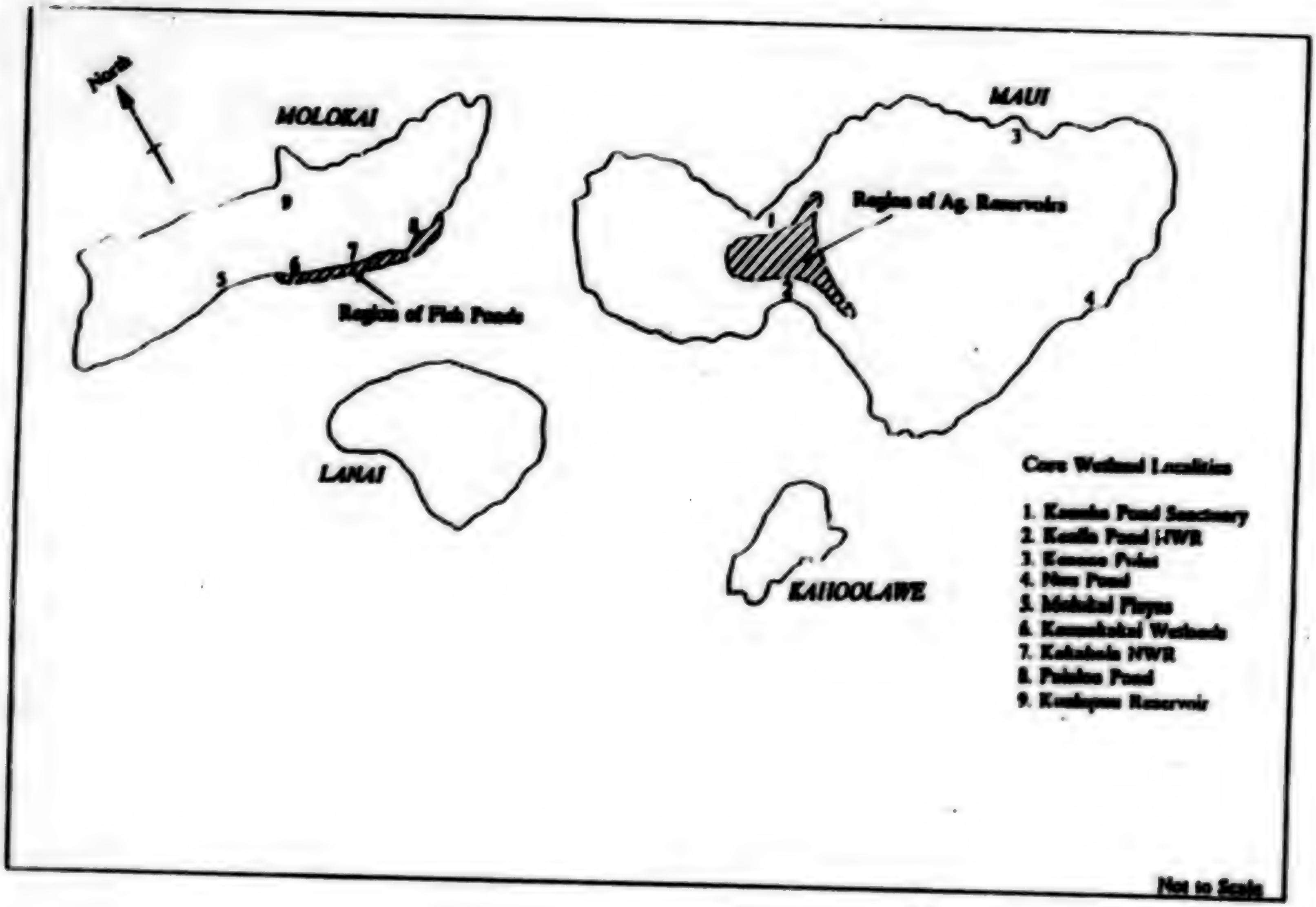


Figure 8. Core wetland localities on the islands of Molokai and Maui.

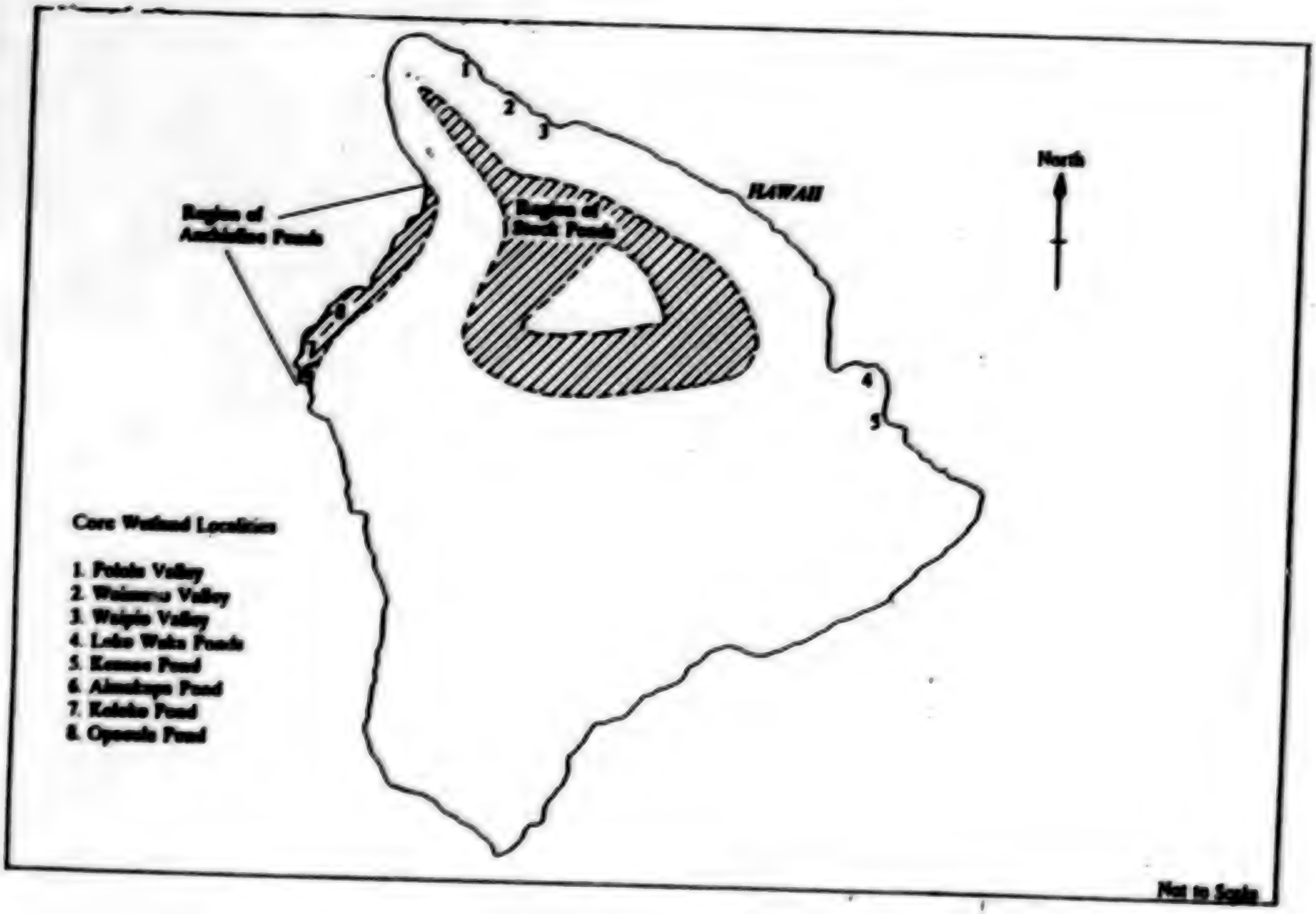
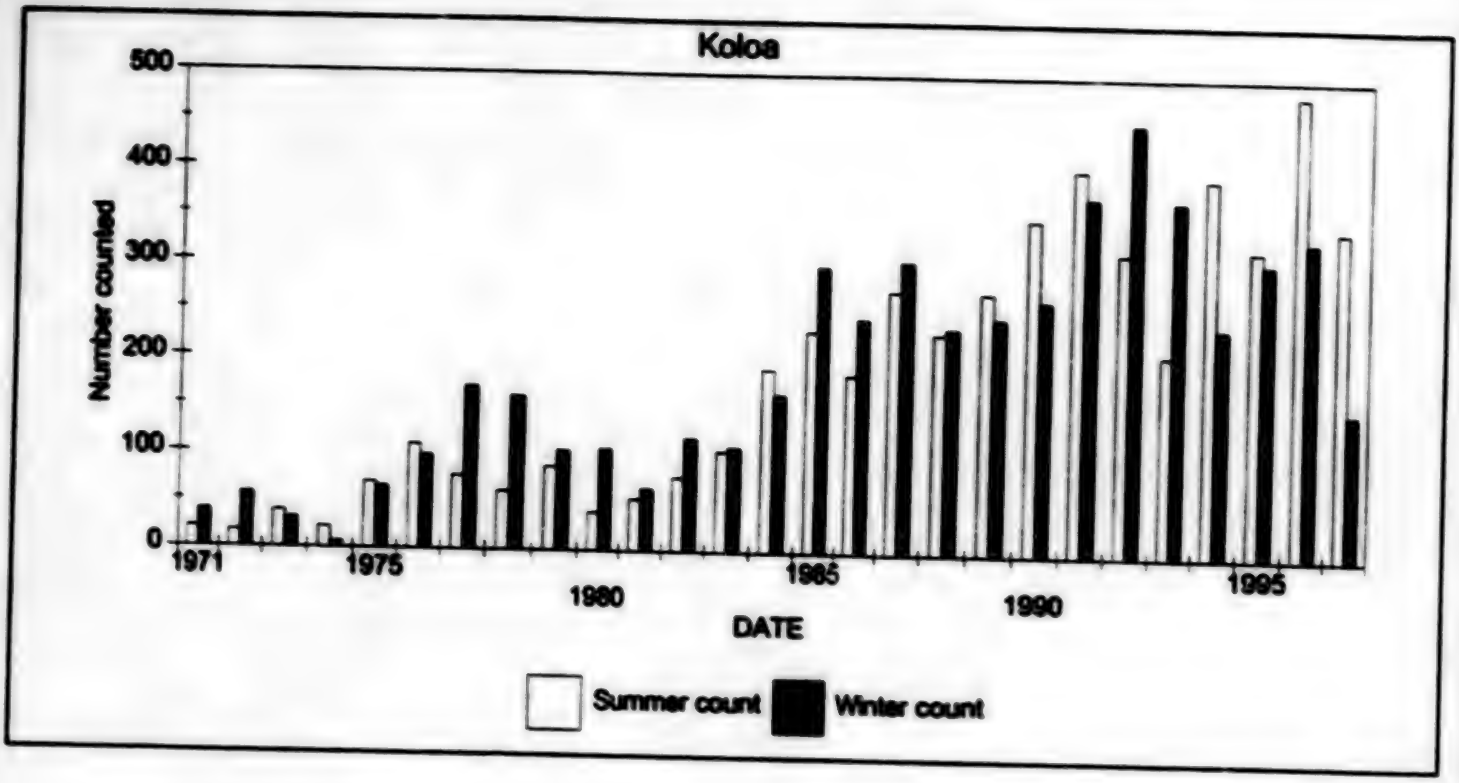
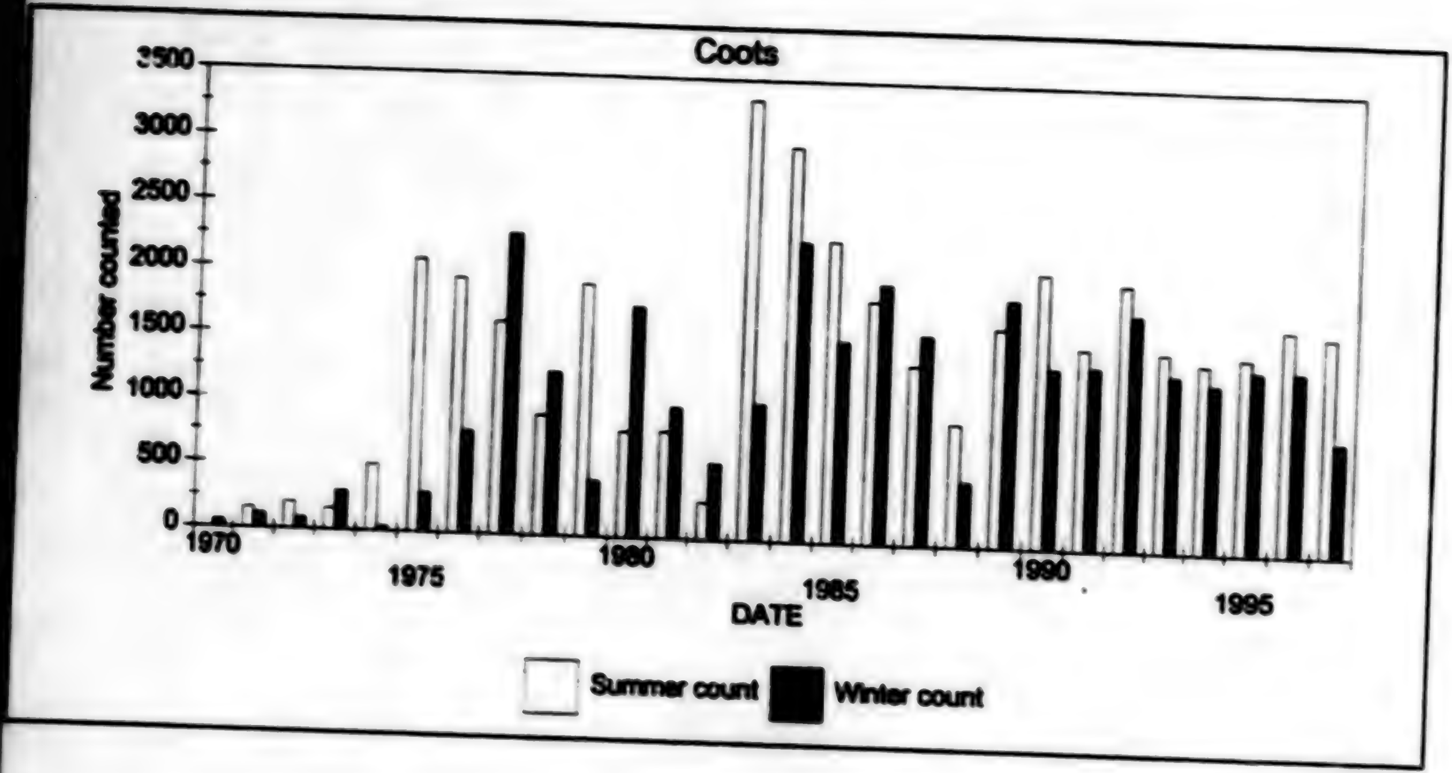


Figure 9. Core wetland localities on the island of Hawaii.

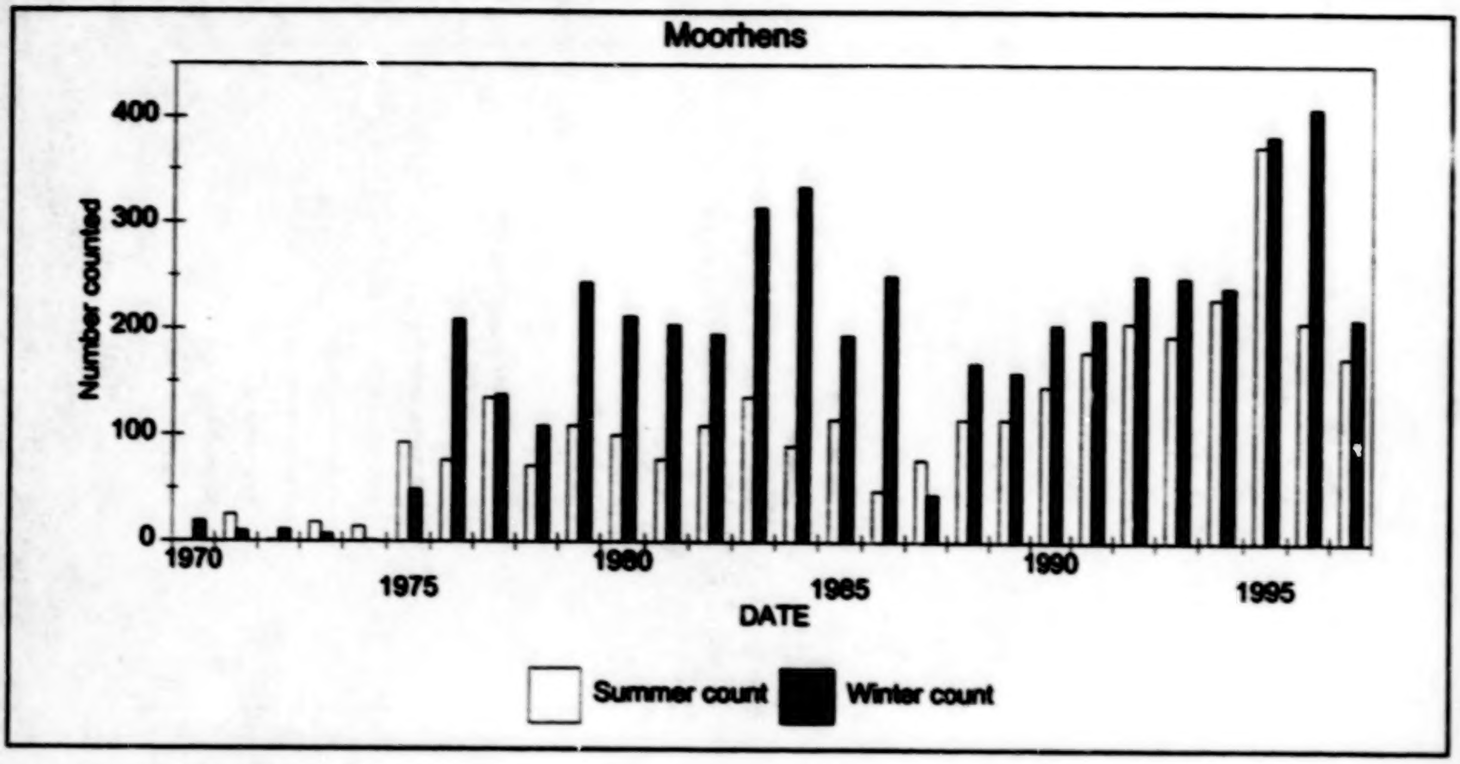
APPENDIX C. Waterbird Counts at Wetland Habitats in the Hawaiian Islands, 1974 to 1997.



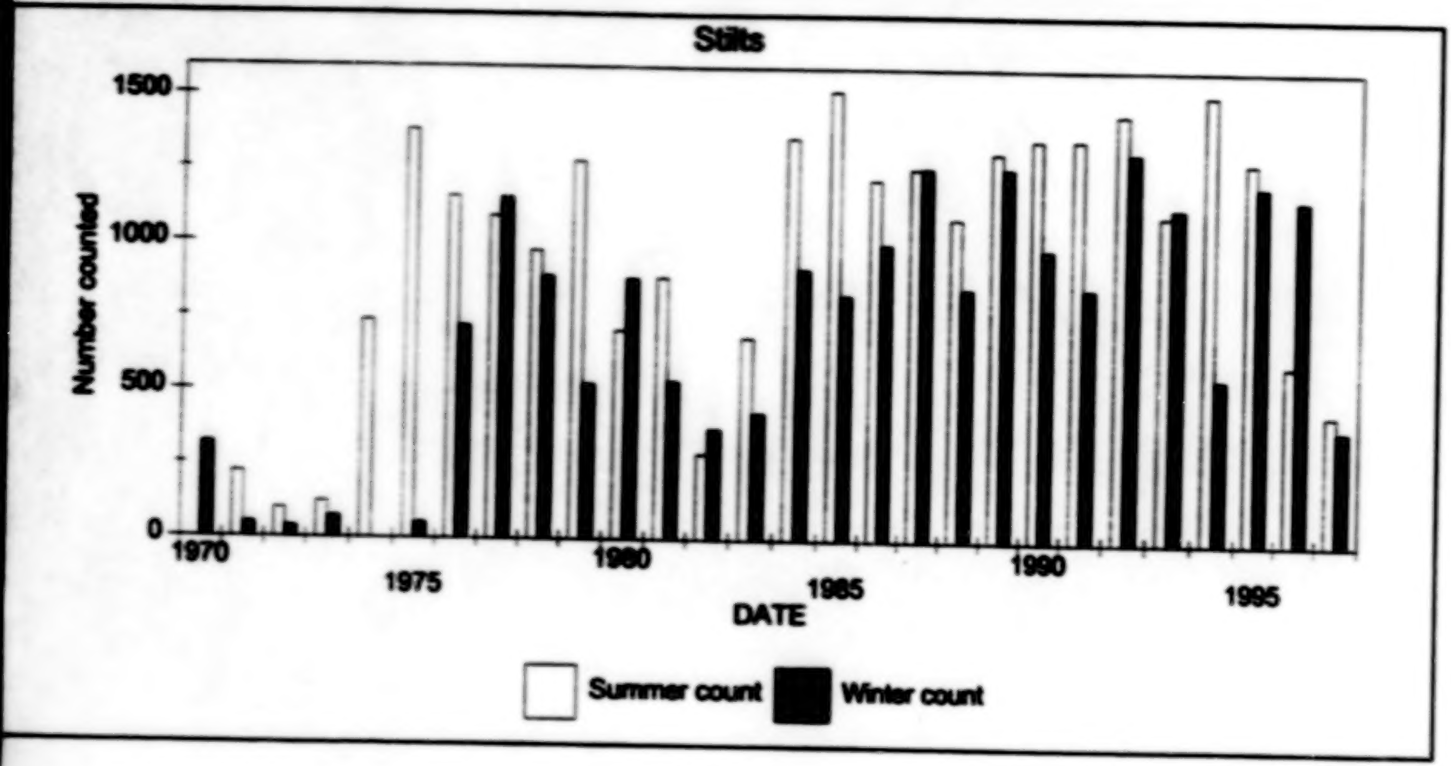
Appendix C1. Counts of Koloa maoli at wetland habitats in the Hawaiian Islands, 1974 to 1997.



Appendix C2. Counts of Hawaiian coots at wetland habitats in the Hawaiian Islands, 1974 to 1997.



Appendix C3. Counts of Hawaiian moorhens at wetland habitats in the Hawaiian Islands, 1974 to 1997.



Appendix C4. Counts of Hawaiian stilts at wetland habitats in the Hawaiian Islands, 1974 to 1997.

END

09-14-99